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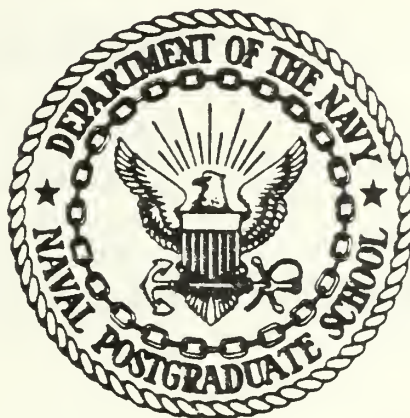
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SOLAR ENERGY DESIGN IMPROVEMENT;
A METHODOLOGY
FOR HYDRONIC FLAT PLATE COLLECTOR SYSTEMS

Lawrence William Kozoyed

NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

SOLAR ENERGY DESIGN IMPROVEMENT;
A METHODOLOGY
FOR HYDRONIC FLAT PLATE COLLECTOR SYSTEMS

by

Lawrence William Kozoyed

September 1979

Thesis Advisor:

M. Kelleher

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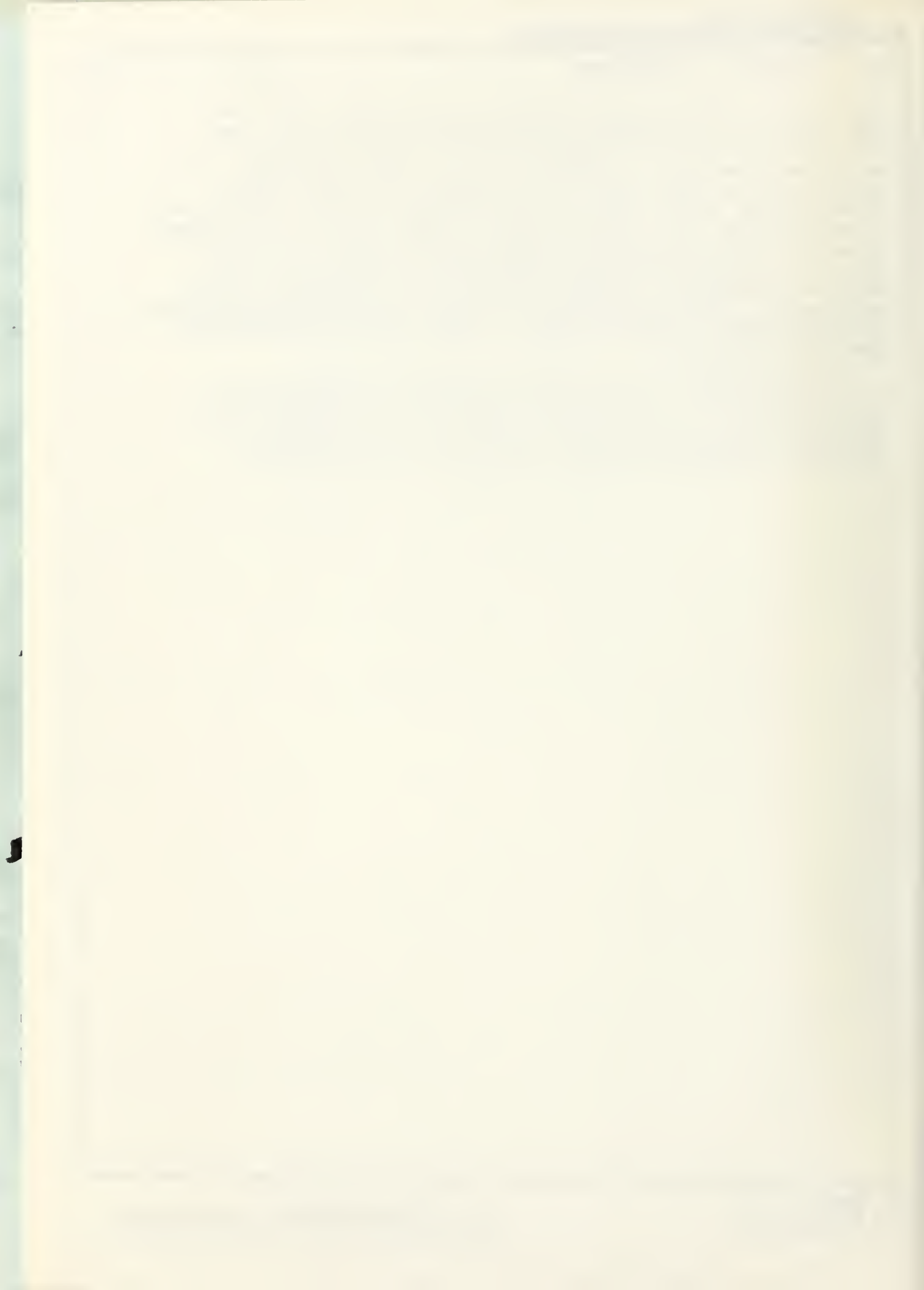
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tilt angle, collector and storage fluid stream velocities, and collector to storage heat exchanger dimensions. The procedure includes an accounting for economic parameters as an intimate part of the design process. The resulting methodology has been used for the design of solar energy systems which would use shelf item collectors for the purposes of determining the optimum design variable vector for a given situation. The methodology could also be used on a limited basis for collector design optimization by exploring the effects of changing selected collector parameters on system performance. The methodology is coded in the FORTRAN computer language under the name SOLOAD-1 (SOLAR ENERGIES OPTIMIZATION ANALISIS OR DESIGN).

Initial system trials indicate complete stability with minimal constraint activations. Based on the results of approximately fifty design experiments using SOLOAD-1, new findings concerning optimum collector tilt angle and an incariant optimum collector flow factor are suggested.



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Solar Energy Design Improvement:
A Methodology
For Hydronic Flat Plate Collector Systems

by

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Lieutenant Commander, United States Navy
B.S.E.P., University of Oklahoma, 1965

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

A methodology for solar energy system design improvement has been developed and coupled with a constrained function optimization code resulting in an automated solar energy system design procedure. The scope of the methodology is limited to systems using flat plate collectors and water as the working fluid.

Eight parameters have been included as independent design variables. The design variables included collector area, collector tile angle, collector and storage fluid stream velocities, and collector to storage heat exchanger dimensions. The procedure includes an accounting for economic parameters as an intimate part of the design process. The resulting methodology has been used for the design of solar energy systems which would use shelf item collectors for the purposes of determining the optimum design variable vector for a given situation. The methodology could also be used on a limited basis for collector design optimization by exploring the effects of changing selected collector parameters on system performance. The methodology is coded in the FORTRAN computer language under the name SOLOAD-1 (SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN).

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TABLE OF CONTENTS

I.	INTRODUCTION -----	12
	A. BACKGROUND -----	12
	B. SCOPE -----	13
	C. OBJECTIVES -----	14
II.	SYSTEM MODEL -----	16
	A. SYSTEM DESCRIPTION -----	16
	B. ENERGY BALANCE -----	16
	C. ECONOMIC ANALYSIS -----	17
	D. THE OBJECTIVE FUNCTION -----	18
III.	SYSTEM OF EQUATIONS -----	20
	A. GENERAL SUMMARY -----	20
	B. SPECIFIC PARAMETERS -----	20
	1. Annual Energy Load, Q_L -----	20
	2. Annual Solar Energy Load Fraction, \bar{f} ---	21
	3. Fuel Cost Parameters -----	27
	4. System Cost Parameters -----	27
IV.	NUMERICAL OPTIMIZATION -----	30
	A. SIMPLE OPTIMIZATION -----	30
	B. THE COPES/CONMIN SYSTEM -----	31
	1. Terminology -----	31
	2. Methodology -----	33
V.	SOLOAD-1 SYSTEM -----	37
VI.	RESULTS -----	38
VII.	CONCLUSIONS -----	40



VIII. RECOMMENDATIONS -----	41
IX. FIGURES -----	43
APPENDIX A: Subroutine Analiz Summary -----	47
APPENDIX B: SOLOAD-1 Computer Program -----	48
APPENDIX C: SOLOAD-1 Data Files -----	70
APPENDIX D: Experiment Report Summaries -----	76
APPENDIX E: Potential Correlation for Optimum Collector Flow Rate -----	228
BIBLIOGRAPHY -----	231
INITIAL DISTRIBUTION LIST -----	233



LIST OF FIGURES

1.	System Model -----	43
2.	Typical \bar{f} vs A_c -----	44
3.	Typical Collector Efficiency Curves -----	45
4.	SOLOAD - COPES/CONMIN Interface -----	46



NOMENCLATURE

English Letter Symbols

A_r	- load heat transfer surface area, ft^2
A_c	- collector area, ft_c^2
C	- capacity, Btu/hr F
C_c	- collector cost, $\$/\text{ft}_c^2$
C_f	- fuel cost, $\$/\text{Btu}$
C_i	- system initial cost per unit collector area, $\$/\text{ft}_c^2$
C_I	- system installation cost per unit collector area, $\$/\text{ft}_c^2$
C_L	- system lifecycle cost, $\$$
C_{pp}	- system annual pumping power cost per unit collector area, $\$/\text{ft}_c^2 \text{ yr}$
C_s	- system lifecycle cost per unit collector area, $\$/\text{ft}_c^2$
C_{tk}	- storage tank cost per unit collector area, $\$/\text{ft}_c^2$
C_v	- lifecycle operation and maintenance cost per unit collector area, $\$/\text{ft}_c^2$
C_x	- collector to storage heat exchanger cost per unit collector area, $\$/\text{ft}_c^2$
c_p	- specific heat, Btu/lb F
d	- monthly diffuse solar insolation on a horizontal surface, $\text{Btu}/\text{ft}^2 \text{ mon}$
d_i	- collector loop inner diameter, ft
d_o	- collector loop out diameter, ft
d_{xi}	- heat exchanger annulus inner diameter, ft
D_{in}	- value of the solar energy, $\$$

D_{out}	- lifecycle cost, \$
$D_{storage}$	- net savings, \$
\bar{f}	- annual fraction of the energy load provided by solar energy
f_i	- monthly fraction of the energy load provided by solar energy
F'	- collector efficiency factor
F''	- collector flow factor
F_m	- system maintenance cost factor
F_r	- collector heat removal factor
F'_r	- collector to heat exchanger efficiency factor
F'_i	- present worth factor
$F(\bar{X})$	- objective function
G	- collector loop flow rate per unit collector area, gpm/ft_c^2
$G_j(\bar{X})$	- inequality constraint
I	- solar insolation on a horizontal surface, Btu/hr ft^2
I_o	- extraterrestrial solar insolation on a horizontal surface, Btu/hr ft^2
I_t	- solar insolation on a surface tilted towards the equator, Btu/hr ft^2
ICALC	- control flag for COPES
L	- heat exchanger length
\dot{m}	- mass flow rate, lb/hr
NCON	- number of constraints
NDV	- number of design variables
NPV	- net present value, \$
q	- iteration number
Q_e	- rate of utilization of auxiliary energy, Btu/hr

Q_{hex}	- rate of energy transfer at the heat exchanger, Btu/hr
Q_L	- rate of energy transfer from the load to the environment, Btu/hr
Q_u	- rate of useful energy collection, Btu/hr
R	- collector tilt correction factor
R_d	- ratio of monthly diffuse insolation on a tilted surface to the monthly direct insolation on a horizontal surface
\bar{R}_D	- average ratio of monthly direct insolation on a tilted surface to the monthly direct insolation on a horizontal surface
R_ρ	- ratio of monthly reflected radiation on a tilted surface to the monthly total radiation on a horizontal surface
s	- collector tilt angle, deg
\bar{S}	- search direction
T_a	- ambient climatic temperature, F
T_i	- collector inlet temperature, F
T_o	- collector outlet temperature, F
T_s	- storage tank outlet temperature, F
U_L	- collector loss coefficient, Btu/hr ft ² F
v_c	- collector loop flow velocity, ft/hr
v_s	- storage loop flow velocity, ft/hr
VLB_i	- lower side constraint for i-th design variable
VUB_i	- upper side constraint for i-th design variable
W_p	- rate of work energy used to maintain system flow, Btu/hr
\bar{X}	- vector of design variables

Greek Letter Symbols

α	- absorptance of the collector absorber surface
α^*	- move parameter in optimization problem
δ	- declination angle of the earth, deg
ϵ	- heat exchanger effectiveness
ζ_1	- 1st collector flow parameter
ζ_2	- 2nd collector flow parameter
η	- collector efficiency
κ^*	- unique flow factor (optimum F'')
κ^{**}	- flow rate proportionality constant, gpm hr F/Btu
ρ	- ground reflectivity
τ	- transmittance of collector covers
ϕ	- latitude angle, deg
ω_s	- sunrise hour angle for horizontal surface, deg
ω_s'	- sunrise hour angle for tilted surface, deg

I. INTRODUCTION

A. BACKGROUND

The control and utilization of energy has become the major issue of this decade: the energy crises. The inflation rate of energy costs and particularly fossil fuel costs has the specter of uncontrollability as this decade comes to a close. Reference [1] reports a 30% increase in the price of oil in 1978 alone. Reports from the media in early September 1979 indicate the price of home heating oil has increased 70% since the 1978 heating season. The crisis center appears to be an emerging realization that the supply of available energy is in fact exhaustible. This realization has spread from a few to the masses; unquestionably the fruit of the Organization of Petroleum Exporting Countries.

In June of 1979, President Carter proposed to the Congress an energy strategy whereby solar energy would be providing 20% of the Nation's energy by the year 2000. For the purposes of domestic hot water (DHW) and residential space heating this goal is technically achievable. The basic solar energy technical theory is well documented by Duffie and Beckman [2] and Kreith and Kreider [3] and the technology is continually being updated in the Solar Energy Journal [4]. The increased effort in solar energy research work is in clear evidence as the documentation in this journal appears to be on an exponential rise.

The treatment of solar energy system performance is typically a determination of the fraction of a given heat load which is provided by solar energy. This fraction, \bar{f} , is a nonlinear function of many system variables but typically increases in a monotonic fashion as a function of collector area. To simply seek maximum \bar{f} and maximum collection of energy in an unconstrained fashion can result in extreme initial system costs. Accordingly, in order to assure a proper balance, technical performance and cost should be considered throughout the design process and economics should become an intimate part of the technical design problem; not an after thought at the end of system design.

The economic ingredient in the problem of solar energy system design has received little attention in the literature. In view of this there is little information in the literature on how to proceed with design improvement of a solar energy system. Accordingly, a broad objective for this work was to develop a solar energy system model including economic considerations and to seek system design improvement by using the resulting eco-technical model together with an optimization algorithm.

B. SCOPE

The conversion of solar energy into useful work covers a broad spectrum of collection schemes. These include thermal, photovoltaic, biological, wind, and ocean thermal energy conversion. Reference [5] is an excellent introductory

information source covering many methods of solar energy conversion and has become a classic. This thesis effort was limited to the thermal conversion of solar radiation for the purpose of generating low temperature heat. Since low temperatures are involved, only flat plate collectors were studied. Flat plate collectors can provide temperatures on the order of 200° F compared to concentrating collectors which can provide temperatures as high as 6700° F. The restrictions on temperature were chosen in keeping with availability analysis; matching the solar conversion system to its task. The task of providing high entropy, low quality DHW and space heating energy is matched with low availability (i.e., minimum utilization of available energy in high quality, low entropy forms such as oil, gas, and central power). The collector working fluid was restricted to water. Further, since the collection of solar energy is a stochastic process, only analysis for long term performance was studied. The analysis of the dynamic performance of specific systems in response to hourly climatic data has previously been conducted by Kline et al [6] and now forms the basis for long term analysis.

C. OBJECTIVE

The objective of this thesis was to develop methodologies for:

1. System synthesis including a determination of optimum system design variables including collector area, collector

tilt angle, heat exchanger sizes, and flow rates. This analysis would be based on using shelf item collectors characterized by performance parameters $F_{r\tau\alpha}$ and F_{rU_L} which have been determined by tests conducted in accordance with refs. [7 and 8].

2. Collector design optimization including a determination of the optimum combination of collector design variables such as materials and geometries; and which would yield the optimum system performance.

Fundamental to the effort was the utilization of:

1. COPES/CONMIN (Control Program for Engineering Synthesis with Constrained Function Minimization), a design improvement algorithm developed by Vanderplaats [9, 10, 11 and 12].

2. Standardized long term solar energy load fraction correlations (f - CHART) developed by Kline [6].

3. Economic considerations combined with technical analysis.

4. Long term climatic data obtained from (NOAA) National Oceanic and Atmospheric Administration [13].

II. SYSTEM MODEL

A. OVERALL SYSTEM DESCRIPTION

A schematic diagram of the solar heating system is shown in Figure 1. The system consists of four heat exchangers, a storage tank and associated system piping. The first heat exchanger is called the collector and is used to transform incident solar radiation into useful thermal energy. At the second heat exchanger the collected energy is transferred to the secondary loop and stored in the form of sensible energy in the storage tank. The sensible energy is transferred from storage to the loads via the third and fourth heat exchangers. Energy transfer is achieved via four forced convection flow loops. This model was further simplified by assuming total utilization of the energy stored in the tank and thereby eliminating the need to detail the DHW and space heating heat exchangers.

B. ENERGY BALANCE

The steady state power balance for the system is

$$Q_u + W_p + Q_e = Q_L \quad (1)$$

where,

Q_u = Useful rate of energy collection (Btu/hr)

W_p = Work energy utilized to maintain system flow

Q_e = Rate of utilization of auxiliary energy which is required in addition to solar energy in order to meet the DHW and space heating load

Q_L = Rate of energy loss by the system

For the purposes of this thesis, it has been assumed that W_p is a known or estimated parameter. Most analyses in the literature do not account for W_p since it is typically assumed to be a very small fraction of the energy required.

The percentage of the energy load which is supplied by solar energy is defined as:

$$\bar{f} = \frac{\sum_i Q_{u,i}}{\sum_i Q_{L,i}} \quad (2)$$

where the summation is taken over 12 monthly values.

\bar{f} is a monotonically increasing function of collector area. No optimum \bar{f} is evident. Figure 2 depicts a typical \bar{f} distribution resulting from a design problem. Since initial costs are strongly dependent on collector area (see Section III), attempts to seek maximum \bar{f} can result in very high initial system costs. At this point the motivation to include economic considerations as a part of the system design model become clear.

C. ECONOMIC ANALYSIS

The matter of economics has been treated as it evolved in this study: a simple common sense approach. This approach includes:

1. An economic equation which utilizes technical parameters obtained from mass, momentum and energy balance considerations together with economic parameters.

2. Standardization of the economic equation by characterization of all terms in present dollar values.

The economic analysis is similar to an energy balance. Considering the economic system as the monetary account of a consumer and the time period as the economic lifetime of the energy conversion equipment:

$$D_{in} = D_{out} + D_{storage} \quad (3)$$

where,

D_{in} = The value in dollars of the energy produced by the equipment

D_{out} = The expense in dollars to obtain, operate and maintain the equipment

$D_{storage}$ = The net savings

The rational consumer seeks maximum $D_{storage}$. This methodology is a simple capital budgeting technique and is contained in any standard reference in accounting or finance.

D. THE OBJECTIVE FUNCTION

Implicit in the use of the economic model is an assumption that the terms in the equation can be expressed as variables of the technical functions which have been defined by the physics of the engineering problem. For

the solar energy system utilized for domestic hot water and space heating the transformation is simple:

$$\text{Net Savings} = \text{Fuel Savings} - \text{System Costs}$$

This equation becomes the objective function by standardizing all dollar amounts to present values. The resulting equation is:

$$\text{NPV} = \bar{f}Q_L C_f F'_i - A_C C_S \quad (4)$$

where,

NPV = Net present value of the solar investment, \$

C_f = Fuel cost for the energy replaced by solar energy, \$/Btu

F'_i = Present worth factor which standardizes fuel savings during system life into present dollars, years

A_C = Collector area, ft_C^2

C_S = System lifecycle cost per unit collector area, $\$/\text{ft}_C^2$

The effort now proceeds to determining each of the above dependent parameters and to obtaining those combinations of these variables which will result in maximum values of NPV.

III. SYSTEM OF EQUATIONS

A. GENERAL

The objective function has been fully developed by examining each of its parameters individually. Completion of this development has resulted in a non linear function of eight independent design variables; a hypersurface in eight space. When formulated in this manner, the problem is clearly not amenable to analytical solution. In a very simple manner however the problem can be interfaced with the design improvement algorithm COPES/CONMIN (see Section IV). The primary contribution for this effort comes from Kline [6] who developed the f-chart correlations for determining monthly solar energy load fractions f_i . The annual load fraction \bar{f} is then computed by a weighted average of the monthly values.

B. SPECIFIC PARAMETERS

1. Annual Energy Load, Q_L

The annual energy load consists of two basic ingredients; the DHW load and the space heating load. Assuming an average mean ground temperature the month to month DHW load was considered constant except for the variation due to month length. The methods for determining the space heating loads typically follow the ASHRAE manual, reference [14]. Reference [15] is recommended as a text for space heating load

computations. For the purposes of this study representative building loss parameters were used. Typical building conductance or $(UA)_r$ values of 30,000, 20,000 and 10,000 (Btu/deg F day) have been used based on a standard building of 1750 ft² of floor area, a heat transfer surface of 5000 ft² and building loss coefficients, U_r , of .25, .17, and .09 Btu/ft² hr F respectively. The conductance, UA, is the space heating load at design conditions which has been estimated in the manner of Ref. [14] and divided by the design temperature difference.

2. Annual Solar Energy Load Fraction, \bar{f}

\bar{f} is a function of collector performance parameters, thermal physical properties of the working fluids, fluid flow rates, heat exchanger performance parameters, collector tilt angle, climatic conditions and latitude. The climatic conditions determine the load distribution (heating degree days), the solar energy flux distribution (insolation) and the environmental stress on the collector (ambient temperature).

a. Collector Performance

A determination of collector performance proceeds from the well known collector equation of Hottel and Whillier [16] which is the result of an energy balance on the collector:

$$Q_u = F_r U_{L,C} (I R \tau \alpha - U_L (T_i - T_a)) \quad (5)$$

where,

Q_u = Useful rate of energy collection (Btu/hr)

F_r = Collector heat removal factor (dimensionless)

U_L = Collector loss coefficient (Btu/hr ft² F)

A_c = Collector area (ft²)

I = Solar insolation on a horizontal surface (Btu/hr ft²)

R = Collector tilt correction factor (dimensionless)

τ = Transmittance of collector cover system (dimensionless)

α = Absorptivity of the collector absorber plate
(dimensionless)

T_i = Collector fluid inlet temperature (F)

T_a = Climatic ambient temperature (F)

The analytical expressions for F_r and U_L are complex and result from a lengthy development which can be found in references [2 and 3]. The computation of F_r and U_L using these expressions is not necessary for system design analysis using shelf item collectors since the parameters $F_r U_L$ and $F_r \tau \alpha$ can be obtained from collector efficiency tests.

Collector efficiency is defined as:

$$\eta = \frac{Q_u / A_c}{IR} \quad (6)$$

Assuming that U_L is not sensitive to changes in the environment and combining equations (4) and (5) results in:

$$\eta = F_r \tau \alpha - F_r U_L ((T_i - T_a) / IR) \quad (7)$$

Equation (7) is linear in the collector parameter $(T_i - T_a)/IR$ and forms the basis for determining collector performance. It is clear that the parameter $F_r U_L$ is obtained from the slope and $F_r \tau \alpha$ is obtained from the intercept of equation (6). Some typical curves of collector efficiency are included in Figure 3.

Two standards have been developed for collector testing to measure collector performance, namely references [7] and [8]. The standards differ in the independent variables used in the performance characterization. Reference [7] the ASHRAE standard uses $T = T_i - T_a$; ref [8] the NBS standard uses $T = (T_i + T_o)/2$, where T_o is the collector outlet temperature. All collector performance test data used in this effort is based on the ASHRAE standard. All collector data used in this effort is based on actual collector tests conducted by NAVFAC and reported via ref [17].

b. Collector to Storage Coupling

The collector becomes coupled to the storage tank via the collector to storage heat exchanger following the method of de Winter [20]. It is assumed that the rate of energy transfer at the heat exchanger is equal to the rate of useful energy collection:

$$Q_{hex} = Q_u = \epsilon (\dot{m} c_p)_{min} (T_o - T_s) \quad (8)$$

where,

T_o = Maximum system temperature or collector outlet

T_s = Minimum system temperature or storage outlet.

Equations (5) and (8) are combined to eliminate

T_i and T_o dependence to give:

$$Q_u = F'_r U_L (IR\tau\alpha - U_L(T_s - T_a)) \quad (9)$$

where,

$$F'_r = F_{hex} F_r \quad (10)$$

$$F_{hex} = \left\{ 1 + \frac{F_r U_L A_c}{(\dot{m}c_p)_c} \left[\frac{(\dot{m}c_p)_c}{\epsilon (\dot{m}c_p)_{min}} - 1 \right] \right\}^{-1} \quad (11)$$

c. Solar Insolation at Optimum Tilt Angle, I_t

The solar radiation intensity on a tilted surface is by definition:

$$I_t = IR \quad (12)$$

Solar insolation is typically measured and reported for a horizontal surface. Improvements in a solar collector installation are sought by tilting the collector to the optimum angle. The computation for

optimum angle is iterative for each design situation.

Several rules of thumb have evolved:

(1) Collectors should be oriented at a slope of .9 times the latitude angle for maximum annual collection.

(2) For DHW systems where loads vary little during the year the best angle of tilt is equal to the latitude angle.

(3) The optimum collector tilt angle for least cost per Btu delivered for building heating is approximately the latitude angle plus 15 degrees.

The methodology for determining collector tilt angle used in this effort was as follows:

(1) Horizontal monthly data was obtained for 97 locations from NOAA in reference [13].

(2) An algorithm was developed to compute monthly horizontal extraterrestrial radiation intensities. This computation is a function of latitude, daily hour angles on horizontal and tilted surfaces, daily declination angle, and collector tilt angle. The azimuth angle was always chosen for a due south collector orientation.

(3) The methodology follows that of Liu and Jordan in reference [19]:

$$R = \left(1 - \frac{d}{I}\right) \bar{R}_D + \frac{d}{I} R_d + R_\rho \quad (13)$$

$$\frac{d}{I} = 1.3903 - 4.0273\left(\frac{I}{I_0}\right) + 5.5315\left(\frac{I}{I_0}\right)^2 - 3.108\left(\frac{I}{I_0}\right)^3 \quad (14)$$

$$R_d = \frac{\omega_s' \sin(\phi-s) \sin \delta + \cos(\phi-s) \cos \delta \sin \omega_s'}{\omega_s \sin \phi \sin \delta + \cos \phi \cos \delta \sin \omega_s} \quad (15)$$

$$\omega_s' = \min[\cos^{-1}(-\tan(\phi-s) \tan \delta), \cos^{-1}(-\tan \phi \tan \delta)] \quad (16)$$

$$\omega_s = \cos^{-1}[-\tan \phi \tan \delta] \quad (17)$$

$$R_d = \frac{1}{2} (1 + \cos s) \quad (18)$$

$$R = \frac{1}{2} (1 - \cos s) \rho \quad (19)$$

where,

R = monthly slope correction factor

\bar{R}_D = average ratio of monthly direct radiation on a tilted surface to monthly direct radiation on a horizontal surface

R_d = ratio of monthly diffuse radiation on a tilted surface to monthly diffuse radiation on a horizontal surface

R_ρ = ratio of monthly reflected radiation on a tilted surface to monthly total radiation on a horizontal surface

$\frac{d}{I}$ = ratio of monthly diffuse radiation on a horizontal surface to monthly total radiation on a horizontal surface

$\frac{I}{I_0}$ = ratio of monthly total radiation on a horizontal surface to monthly total extraterrestrial radiation on a horizontal surface

ω_s = sunrise hour angle on a horizontal surface

ω_s' = sunrise hour angle on a tilted surface

s = collector tilt angle
 ϕ = latitude angle at collector site
 δ = declination angle of the earth
 ρ = ground reflectance for area adjacent to collector.

3. Fuel Cost Parameters

Fuel cost parameters included a selection from among 3 fuel types (i.e. oil, electricity, or gas), unit of issue cost, fuel heating value and efficiency of the auxiliary heating system. The SOLOAD-1 system allows complete freedom in the selection of these parameters. A typical set of fuel cost parameters used in a design experiment included:

Fuel:	Oil
Unit Cost:	.9 (\$/Gal)
Heating value:	142,000 (Btu/Gal)
Efficiency:	.7
Resulting Fuel Cost:	$C_f = \$9.05 \text{ per } 10^6 \text{ Btu}$

4. System Cost Parameters

System cost considerations typically include initial costs and life cycle costs for operation and maintenance. Detailed guidance for complete cost considerations is included in ref. [3]. Further, reference [20] contains guidance to be used in determining costs for US Navy installations. The following cost parameters were used in SOLOAD-1:

$$C_L = A_c C_s \quad (20)$$

where,

C_L = Total system life cycle cost

C_s = Total cost per square foot

$$C_s = C_i + C_v \quad (21)$$

$$C_i = C_c + C_I + C_{tk} + C_x \quad (22)$$

$$C_v = F'_i (C_i F_m + C_p) \quad (23)$$

where,

C_i = Initial system cost

C_v = Operation and maintenance costs

C_c = Collector cost

C_I = System installation cost

C_{tk} = Storage tank costs

C_x = Collector to storage heat exchanger costs

C_p = Pumping power costs

F_m = Maintenance cost factor

F'_i = Present worth factor

$$F'_i = \frac{1 - (1 + i')^{-N}}{i'} \quad (24)$$

where,

$$i' = \frac{i - j}{1 + j} \quad (25)$$

i = Discount rate

j = Fuel inflation rate

N = System life in years

It should be noted that F'_i occurs explicitly in the first term of the objective function and implicitly in the second term. It should also be noted that initial costs are not amortized in the SOLOAD-1 model.

IV. NUMERICAL OPTIMIZATION

A. SIMPLE OPTIMIZATION

Design problems typically seek the minimization or maximization of an appropriate parameter within a framework of constraint specifications. The parameter to be optimized may be a function of several design variables and is termed the objective function. Other parameters which may be separate functions of design variables must not exceed specified bounds for the design to be acceptable. These parameters are termed design constraints and are not to be confused with limits which may be set on design variables which are usually termed side constraints.

Engineering problems can be numerically coded for an analysis (once through) solution. The simplest scheme for optimization may consist of a series of loops through the computer code which may cycle many combinations of design variables. The combination of variables which provides the best design and which also satisfies the constraints is then considered optimum. This approach may be economical for a design problem with just a few design variables and short computer time requirements. A design problem with 3 design variables, ten values for each design variable, and one-tenth seconds central processing unit (CPU) time for each analysis would take a total of 100 seconds of CPU time. The solar energy optimization design problem as characterized

by the code developed by this thesis has a minimum of 8 design variables; each analysis of its objective function requires about 2 CPU seconds. Using the simple approach and assuming ten values for each design variable would result in a CPU time of 68 years for each design problem. Clearly, a more rational approach to optimization is necessary.

Vanderplaats [9] suggested that many special algorithms for numerical optimization have been proposed in recent years, but that in many cases unsuspecting practitioners find their particular optimization problem unsolved only after large amounts of time and effort are expended. This can occur usually because of inexperience by the practitioner in determining the limitations of specified algorithms. Vanderplaats [10, 11, and 12] has developed a FORTRAN coded algorithm capable of optimizing a very wide class of engineering problems. The system includes COPES (Control Program for Engineering Synthesis) and CONMIN (Constrained function Minimization). This optimization system is referred to as COPES/CONMIN.

B. THE COPES/CONMIN SYSTEM

1. Terminology

CONMIN is a FORTRAN program in subroutine form for the solution of linear or non-linear constrained optimization problems. The user prepares an analysis program. The

program must be named SUBROUTINE ANALIZ. The process of computer aided design or of trade off studies with a minimum of man-machine interaction becomes fully automated via the COPES program. Three basic definitions are required:

Design Variables. Those parameters which the optimization program (CONMIN) is allowed to change in order to improve the design. Design variables appear only on the right hand side of equations in the analysis program (ANALIZ). Limits imposed on design variables are termed side constraints.

Objective Function. Usually the single parameter which is to be minimized or maximized during optimization. The objective function always occurs on the left side of the equation in the analysis program. (Refer to [12] for exceptions.) The equation defining the objective function may be linear or non-linear, implicit or explicit, but must be a function of the design variables to be meaningful.

Design Constraints. Any parameter which must not exceed specified bounds for the design to be acceptable. Constraint parameters always appear on the left side of the constraint function equations. Constraint functions may be linear or non-linear, implicit or explicit, but must be functions of the design variables.

Assuming that the optimization process requires the maximization of a particular objective function, the general optimization problem can be stated as:

a. Find: \bar{X} which maximizes $f(\bar{X})$

b. Subject to:

(1) CONSTRAINT EQUATIONS $G_j(\bar{X}) \leq 0, j = 1, NCON$

(2) SIDE CONSTRAINTS $VLB_i \leq X_i \leq VUB_i, i = 1, NDV$

Where, $\bar{X} = \bar{X}(X_1, X_2, \dots, X_n)$ is the vector of NDV design variables, $F(\bar{X})$ is the objective function and $G_j(\bar{X})$ are the set of NCON constraints. VLB_i and VUB_i are the lower and upper bounds respectively on each design variable.

2. Methodology

The solution process proceeds as follows:

a. The user prepares an analysis subroutine which defines \bar{X} , $F(\bar{X})$ and $G_j(\bar{X})$. This subroutine must be named ANALIZ. ANALIZ must have three segments; input, analysis and output keyed to COPES flags, ICALC = 1, 2, or 3 respectively.

b. The user prepares an input data file for COPES which includes a wide variety of system options, appropriate matching mechanisms between ANALIZ and CONMIN and the constraint boundaries.

c. Using the initial vector of design variables COPES obtains an initial solution from ANALIZ and subsequent solutions by updating \bar{X} as determined by CONMIN. Any analysis solution which satisfies the constraint equations and the side constraints is a feasible design. If an analytical solution violates any of these constraints it is an infeasible design. The minimum feasible design is optimal.

The feasibility determination includes:

(1) If a constraint equation is violated (i.e., if $G_j(\bar{X}) > 0$) then the j th constraint is violated.

(2) If a constraint equation equality condition is met (i.e., if $G_j(\bar{X}) = 0$) then the j th constraint is active.

(3) If a constraint equation condition is met (i.e., if $G_j(\bar{X}) < 0$) then the constraint is inactive.

Note that CONMIN is designed to minimize objective functions; the process of maximizing an objective function is concerned with minimizing the negative of an objective function.

(4) Similarly, side constraints may be inactive or active but side constraints will never be violated in a particular analysis computation because they are specified limits not dependent variables which is the case for design constraints.

(5) All inequality conditions are represented by a band around the zero condition due to computer limitations in defining zero.

d. If the initial analysis solution is infeasible CONMIN moves towards a feasible solution by adjusting the design variables appropriately. The optimization process then proceeds in an iterative fashion as follows:

(1) The iterations are governed by the recursion relation:

$$\bar{X}^{q+1} = \bar{X}^q + \alpha^* \bar{S}^q$$

where,

q = iteration number

α^* = a scalar move parameter which defines the distance of travel in the direction of search

\bar{S} = direction of search

(2) \bar{S} is determined such that $\bar{F}(\bar{X})$ will be minimized without violating any constraints. CONMIN calculates the gradient of $\bar{F}(\bar{X})$ by using finite difference techniques. Because no constraints are violated, the greatest improvement in $F(\bar{X})$ will be realized by moving in the direction of steepest ascent, the gradient of $F(\bar{X})$.

(3) Once the directive is known, the move parameter, α^* , which will allow the largest magnitude improvement in $F(X)$ is to be found. A one dimensioned search of the \bar{S} direction is carried out until the best improvement number, α^* , is found.

(4) CONMIN utilizes methods other than the method of steepest descent in determining \bar{S} particularly in the presence of active constraints. These methods include the method of conjugate directions developed by Fletcher and Reeves [21] and the method of feasible directions developed by Zoutendijh [22] and implemented by Vanderplaats and Moses [23].

e. CONMIN continues to iterate for an optimal design by computing successive \bar{S} and α^* values always keeping within the defined constraints. If there is no relative or absolute change in $\bar{F}(\bar{X})$ for three successive iterations, the optimum is considered found.

V. SOLOAD-1 SYSTEM

A FORTRAN coded algorithm for the analysis of systems containing shelf item collectors has been developed. The algorithm has been named SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN (SOLOAD-1). The portions of the algorithm reserved for design optimization of collectors were not completed and have not been included in SOLOAD-1. The interface between SOLOAD-1 and COPES/CONMIN has been developed via the Control Program (CP-67) and the Cambridge Monitor System (CMS) a time-sharing system developed for the IBM System 360 Model 67. SOLOAD-1 includes:

A. Three executive programs to provide the interfaces among the system elements and to initiate design problems.

B. An analysis subroutine which includes the system of equations covered in Section III. A summary of the objective function, design variables, and design constraints is included in Appendix A.

C. Three auxiliary subroutines including a calendar data array, climatic data and user defined input parameters.

D. Data files for user input to SOLOAD-1 and COPES/CONMIN.

The interface among SOLOAD-1 system elements and COPES/CONMIN is shown in Figure 3. SOLOAD-1 programs and subroutines are included in Appendix B. Data files are included in Appendix C.

VI. RESULTS

A. GENERAL

The first objective of developing a methodology for the analysis of systems with previously defined collector design was achieved. The second objective of developing a methodology for optimizing the collector component design was not achieved. However, it appears that the potential exists for using the system analysis methodology to obtain improvements in collector design. For example, if cost data on various types of collector cover plates or collector absorber surfaces can be correlated with collector performance parameters, then the system model could be used for quick checks on collector design improvements.

B. VERIFICATION

A single design problem was selected and started using 10 different sets of the starting design variable vector. The same optimal design result within $\pm 0.5\%$ was achieved for each run. This was the only actual verification deemed possible at this time due to lack of any known optimization data in the literature.

C. EXPERIMENTS

Approximately 50 design experiments were analyzed. Each problem was characterized by a unique identification number which could tie together the location, economic

environment, the collector, and the space heat transfer coefficient, UA, for the experiment. For each experiment an input parameter summary report and output parameter and results summary report was generated. These reports are included in Appendix D.

D. SPECIFIC RESULTS

1. Constraints

The only active design constraint in most experiments was the tube thickness in the collector loop at the heat exchanger. Some experiments resulted in no active design constraints. There were no active side constraints in any experiment.

2. Collector Flow Factor

The collector flow factor F'' is defined as the ratio of the collector heat removal factor to the collector efficiency factor:

$$F'' = \frac{F_r}{F'}$$

The flow factor result obtained in all optimization experiments was the same. $F'' = .948 \pm .008$.

3. Collector Tilt Angle

Each experiment conducted for a particular geographical location resulted in the same collector tilt angle. However, experiments for different locations but the same latitude resulted in significantly different optimum collector tilt angles.

VII. CONCLUSIONS

A. The SOLOAD-1 system in conjunction with COPES/CONMIN appears to offer the potential for further improvement and potentially a valuable automated technique for solar energy system design.

B. The "rule of thumb" typically used for collector tilt angle optimization (i.e., latitude plus 15°) should be used with caution since preliminary results indicate a strong tendency for climatic dependency.

C. The uniqueness of the flow factor was suggested by the continued result of $.948 \pm .008$ for each experiment. Pending confirmation by further testing it appears that a simple correlation for determining optimum collector loop flow rates may be available. Based on a flow factor of 0.948 the resulting correlation would be:

$$G = .01955 F_r U_L \quad (\text{gpm/ft}^2 \text{ of collector area})$$

This correlation is developed in Appendix E.

VIII. RECOMMENDATIONS

A. The basic model of SOLOAD-1 should be upgraded to include specific characterization instead of simple parameter selection and input for:

1. Pumping power in all four loops
2. Inclusion of the DHW heat exchanger
3. Inclusion of the space heat exchanger
4. Inclusion of building loss coefficients as a design variable.

B. Prior to any additional experiments with the present model, a complete survey of the industry should be conducted for collector parameters and costs. Following this survey, a series of experiments should be conducted in search of correlations among collector performance parameters (i.e., $F_r(\tau\alpha)$ and $F_r U_L$), collector unit costs, and system performance.

C. A larger sample size should be used to verify the uniqueness of the optimum collector flow factor (F'') as suggested by the results of 50 experiments.

D. The remainder of the NOAA climatic data bank (i.e., 67 more cities) should be included in SOLOAD-1. The optimum collector tilt angle could then be computed for the 97 NOAA regions.

E. The model should be upgraded to accommodate analysis for systems with air as the working fluid.

F. The model should be upgraded to accommodate amortization of the installation cost instead of just initial cash payment.

IX. FIGURES

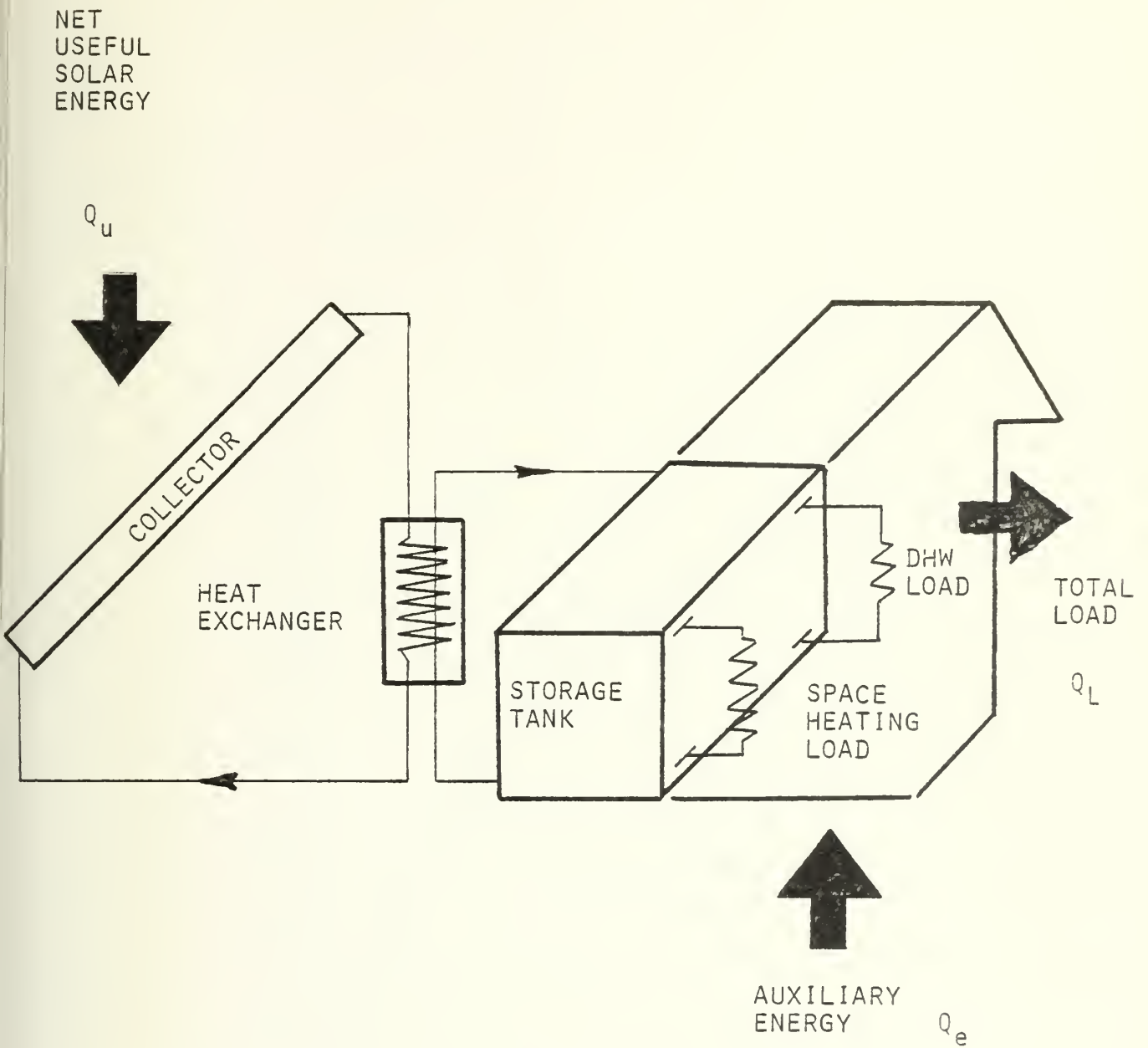


FIGURE 1 System Model

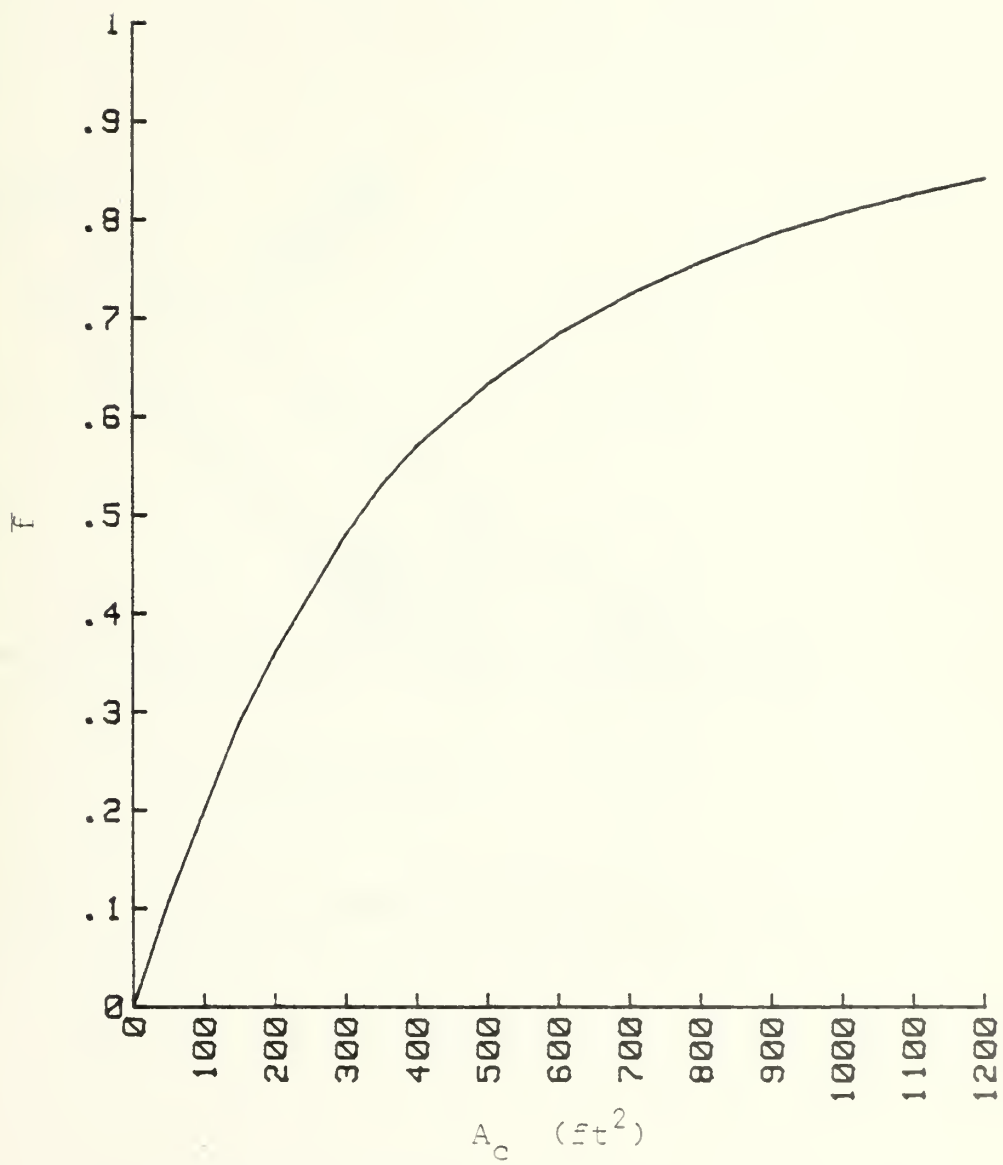


FIGURE 2 Typical \bar{F} vs A_c

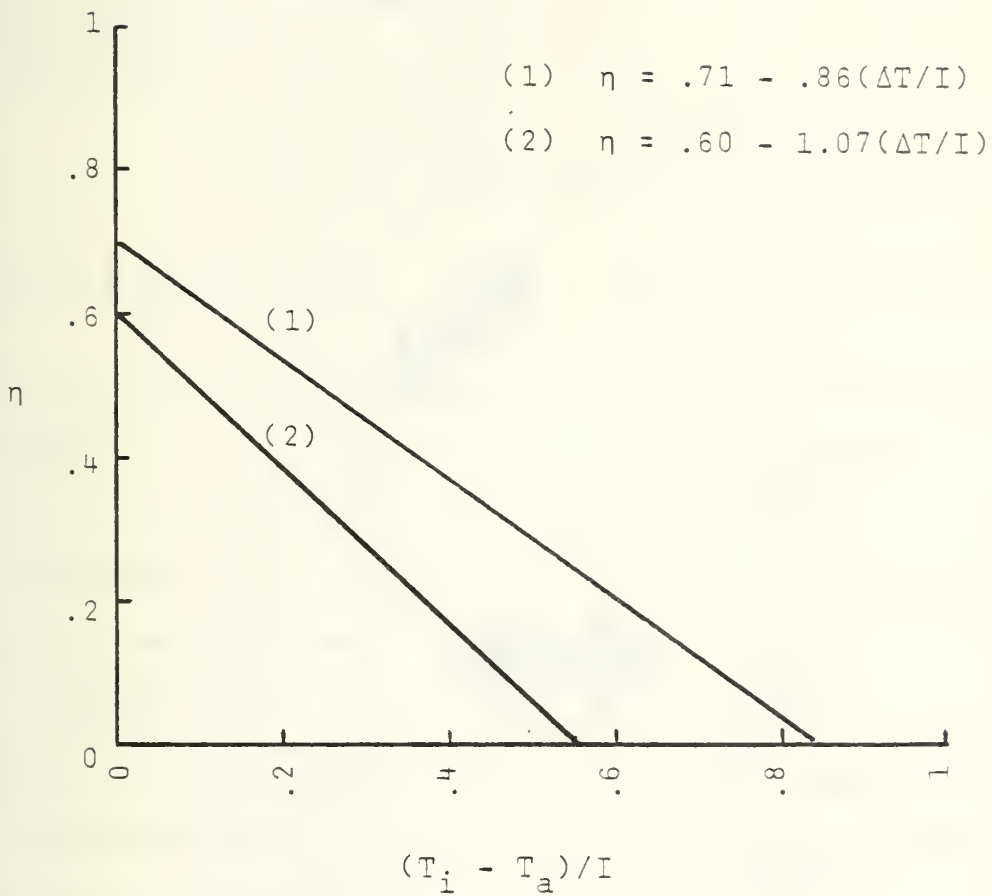


FIGURE 3 Typical Collector Efficiency Curves

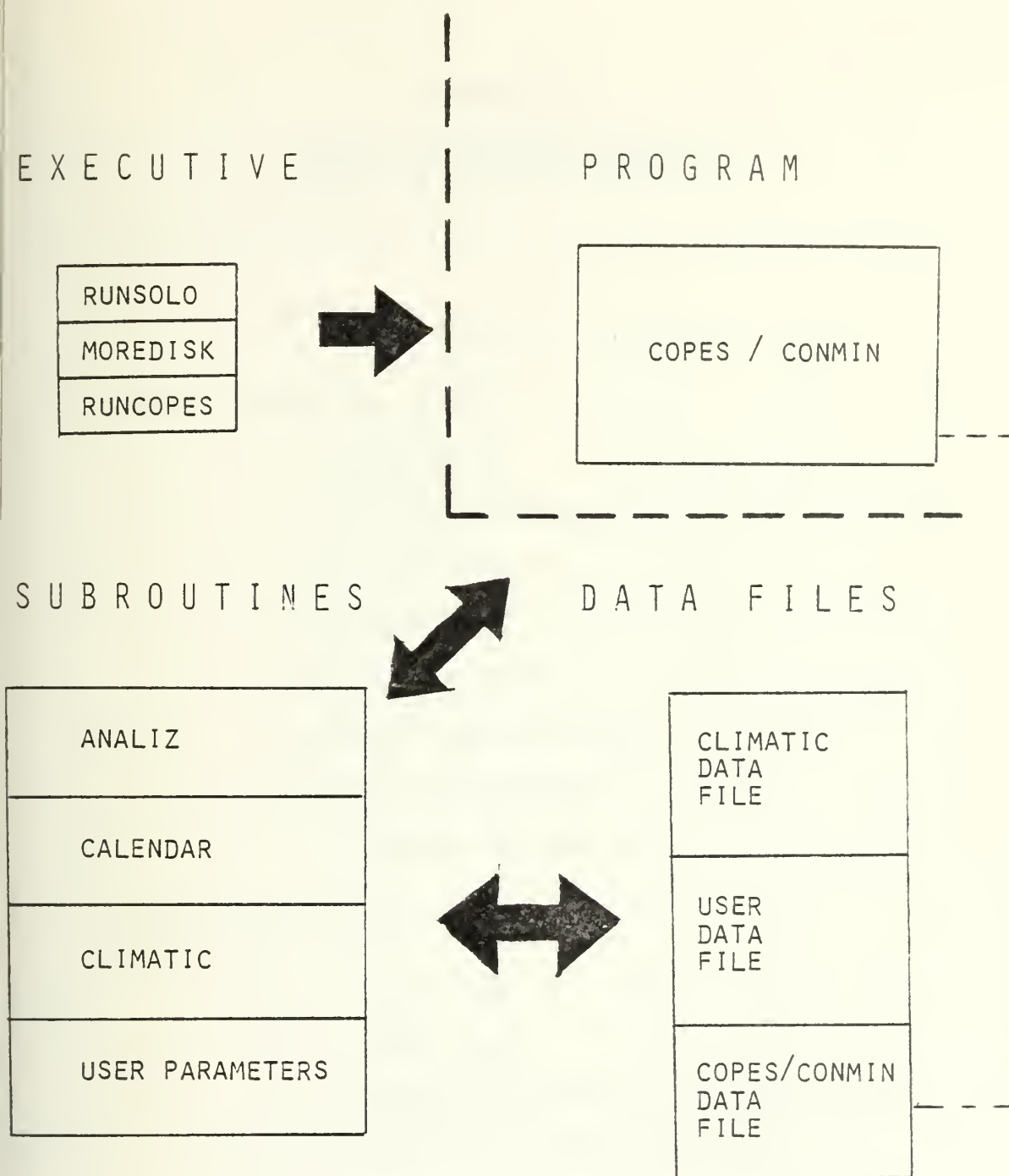


FIGURE 4 SOLOAD - COPES/CONMIN Interface

APPENDIX A

SUBROUTINE ANALIZ SUMMARY

A. OBJECTIVE FUNCTION

$$NPV = \bar{F} Q_L C_f F'_i - A_c C_s$$

B. DESIGN VARIABLES

Collector Area	A_c
Collector Tilt Angle	s
Collector Loop I.D.	d_i
Collector Loop O.D.	d_o
Heat Exchanger I.D.	d_{xi}
Collector Flow Velocity	v_c
Storage Flow Velocity	v_s
Heat Exchanger Length	L

C. DESIGN CONSTRAINTS

$$\begin{aligned}
 G_1 &= d_o - d_i \\
 G_2 &= d_{xi} - d_o \\
 G_3 &= \text{Reynolds number, Collector loop} \\
 G_4 &= \text{Reynolds number, Storage loop} \\
 G_5 &= \text{Capacity ratio, } C_{\min}/C_{\max} \\
 G_6 &= \text{1st Flow parameter, } \zeta_1 = \dot{m}c_p/A_c F' U_L \\
 G_7 &= \text{2nd Flow parameter, } \zeta_2 = \dot{m}c_p/A_c F_r U_L
 \end{aligned}$$

SOLOAD-1 Computer Program

48

5.	MOREDISK TO OBTAIN SCRATCH FILES FOR COPES/CONMIN	SOL0C49C
6.	RUN COPES TO EXECUTE SYSTEM	SOL00500
		SOL00510
		SOL00520
		SOL00530
	RUNSOLO IS AN EXECUTIVE PROGRAM WHICH LINKS THE USER(191) TO	SOL00540
	THE COPES/CONMIN DISK (I.E. LOCATED ON USERIC: 0981P) AND TO	SOL00550
	ADDITIONAL TEMPORARY STORAGE DISKS.	SOL00560
		SOL0C57C
	MOREDISK IS AN EXEC PROGRAM WHICH OBTAINS ADDITIONAL TEMPORARY	SOL00580
	STORAGE DISKS.	SOL00590
		SOL0060C
		SOL00610
		SOL00620
	RUNCOPES IS AN EXEC PROGRAM WHICH COMBINES THE FILES AND EXECUTES	SOL0063C
	THE SYSTEM.	SOL00640
		SOL00650
		SOL00660
	BACKON IS AN EXEC PROGRAM FOR REENTRY INTO THE SYSTEM IF THE	SOL00670
	CMS IS LOST TO CP.	SOL00680
		SOLCC65C
		SOL00700
	ANALYSE IS THE FILE NAME OF THE FORTRAN SUBROUTINE ANALIZ	SOL00710
	AND IS USED IN TEXT VERSION	SOL00720
		SOL00730
		SOL00740
		SOL00750
	SETCAL IS A SUBROUTINE WHICH BUILDS A CALENDAR ARRAY.	SOL00760
		SOL00770
		SOL00780
		SOL00790
	FILE08 IS A SUBROUTINE TO READ IN THE USER DEFINED CONSTANTS	SOL00800
	IN PROGRAM ANALIZ. READIN IS FROM FILE FT08F001.	SOL00810
		SOL00820
	CMATIC IS A SUBROUTINE WHICH BUILDS THE CLIMATIC DATA	SOL00830
	ARRAY CLIMAT(I,J,K) BY READING IN DATA FROM FILE FT09F001.	SOL00840
		SOL00850
		SOL0086C
		SOL00870
	FILE FT05F001 IS AN INPUT DATA FILE FOR COPES/CONMIN WHICH	SOL00880
	IS PREPARED BY THE USER.	SOL0C89C
		SOL00900
		SOL00910
		SOLCC52C
		SOL00930
		SOL00940
		SOLC055C
		SOL00960

RUNSOLO EXEC P1

CF LINK 0981P 191 199 R PASS= COPES
LOGIN 199 A,P

CC

DEFINITIONS

XLIFE = LIFE NUMBER OF SYSTEM (YR)
 DISCON = PROJECTED DISCOUNT RATE OVER LIFE OF SYSTEM
 FLATE = PROJECTED INFLATION RATE OVER LIFE OF SYSTEM

COSTILL = INITIAL COST
 COSTCR = COLLECTOR COST QUOTED BY MFR (\$/FT*FT)
 COSTIN = SYSTEM INSTALLATION COST (\$/FT*FT)
 COSTTK = STORAGE TANK COST PER LB FLUID (\$/LB)
 OPTSTO = OPTIMUM STORAGE MASS PER COLLECTOR AREA (LB/FT*FT)
 COSTHX = HEAT EXCHANGER COST PER HEX SURFACE (\$/HEX FT*FT)
 OPTHEX = OPTIMUM HEX SURFACE AREA PER COLLECTOR AREA (HEX FT*FT/CR FT*FT)

XMR = PERCENTAGE OF INITIAL CCST FOR MAINTENANCE, REPAIR AND/OR REPLACEMENT

COSTPR = ANNUAL POWER COST TO OPERATE SYSTEM PER COLLECTOR AREA

PUMPOW = PUMPING ENERGY REQUIRED (KWHR/FT*FT)
 NFUEL = COMPARISON BASE INDICATOR: 1=OIL, 2=ELE, 3=GAS

UOSSR = CONDUCTANCE OF BUILDING (BTU/HR FT*FT F)
 AREA = SURFACE HEAT TRANSFER AREA OF BUILDING (FT*FT)
 HDD(I) = MONTHLY HEATING DEGREE DAYS (HDD/MONTH)
 DENTS = NUMBER OF RESIDENTS OF BUILDING (PER)
 USEH2O = AVERAGE DAILY WATER USAGE PER RESIDENT (GAL/PER)
 TEMH2O = DHW SUPPLY TANK DESIGN TEMPERATURE (F)
 TEMGR = MEAN TEMPERATURE OF GROUND SUPPLY WATER (F)

I = MONTHLY INDEX 1,12
 J = DAILY INDEX 1,365
 K = BEGINNING DAY NUMBER FOR MONTH I
 L = ENDING DAY NUMBER FOR MONTH I
 XXX(I, J) = CALENDAR ARRAY: J=1 MONTHLY DAYS, J=2 MONTHLY BEGINNING DAY NUMBER, J=3 ENDING DAY NUMBER
 CELTA(M) = DECLINATION, RADIAN
 XOMEGA(M) = DAILY HOUR ANGLE ON HORIZONTAL SURFACE
 SOMEGA(M) = DAILY HOUR ANGLE ON TILTED SURFACE
 FOMEGA(M) = MINIMUM DAILY HOUR ANGLE (H OR T)
 DDRAT(M) = DAILY RATIO OF DIRECT RADIATION COMPONENTS, TILTED TO HORIZONTAL
 CIO(M) = DAILY IRRADIANCE ON HORIZONTAL SURFACE AT LATITUDE OF INTEREST, EXTRATERRESTRIAL

SOL01420
 SOL01430
 SOL01440
 SOL01450
 SOL01460
 SOL01470
 SOL01480
 SOL01490
 SOL01500
 SOL01510
 SOL01520
 SOL01530
 SOL01540
 SOL01550
 SOL01560
 SOL01570
 SOL01580
 SOL01590
 SOL01600
 SOL01610
 SOL01620
 SOL01630
 SOL01640
 SOL01650
 SOL01660
 SOL01670
 SOL01680
 SOL01690
 SOL01700
 SOL01710
 SOL01720
 SOL01730
 SOL01740
 SOL01750
 SOL01760
 SOL01770
 SOL01780
 SOL01790
 SOL01800
 SOL01810
 SOL01820
 SOL01830
 SOL01840
 SOL01850

```

DIRRAT(I) = MONTHLY AVERAGE RATIO OF DIRECT COMPONENTS
XIO(I) = MONTHLY AVERAGE DAILY IRRADIANCE CN HORIZONTAL
        SURFACE, EXTRATERRESTRIAL
XKT(I) = RATIO OF TOTAL HORIZONTAL RADIATION AT LOCATION
        ON OF INTEREST, LOCAL TO EXTRATERRESTRIAL
CIFRAT(I) = RATIO OF DIFFUSE TO TOTAL RADIATION ON HORIZONTAL
        SURFACE (LIUE&JCRDAN CORRELATION)
RHO = REFLECTIVITY OF GROUND AREA NEAR COLLECTOR
SLOPE = ANGLE AT WHICH COLLECTOR IS TILTED FROM THE
        HORIZONTAL, FIXED FOR ALL MCNTHS
SLOCOR(I) = MONTHLY AVERAGE DAILY IRRADIANCE RATIO,
        TILTED TO HORIZONTAL

```

```

SUMFQ = ANNUAL ENERGY LOAD PROVIDED BY SOLAR (BTU/YR)
COSTFU = COST OF CONVENTIONAL ENERGY IN THE YEAR ANALYSIS
        IS CONDUCTED. ($/BTU)
INTFAC = INTEREST FACTOR (INCLUDES INFLATION AND CCST OF
        MONEY FACTORS)
AREAC = COLLECTOR AREA (SQFT)
COSTSY = TOTAL SYSTEM COST COMPUTED PER COLLECTOR AREA
        ($/SQFT)

```

SCLOAD-1 FCRT RAN P1

SUBROUTINE ANALIZ(ICALC)

LOGICAL LANA,LDES

COMMON/ GLOB CM/AREAC, SLOPE, DIACIO, DIAC TI, DIA STI, VELOC, VELQS,
 *HX LONG, XNPV, G1, G2, G3, G4, G5, G6, G7, COSTEN, OPTSLO, FBAR, SUMQ

COMMON/ FILE 89/LOCATE

COMMON/ DAYS/XXX(12,3)

COMMON/FILE 8/NAME1, NAME2, NAME3, NAME4,
 *LANA, LDES, NFUEL,

*NAME5, NAME6, NAME7, NAME8, NAME9, FRTA, FRUL,
 *TARAT, RHO, C SUBPC, C SUBPS, XLIFE, DISCCN, FLATE,
 *CCSTCR, COSTIN, COSTTK, OPTSTO, COSTHX, PUMPOH,
 *CSTOIL, CSTELE, CSTGAS, EFFOIL, EFFELE, EFFGAS,
 *ULOSSR, AREAR, DENTS, USEH2O, TEMH2O, TEMGR,

SOL0186C
 SOL01870
 SOL01880
 SOL01890
 SOL01900
 SOL0191C
 SOL01920
 SOL01930
 SOL01940
 SOL01950
 SOL01960
 SOL01970
 SOL01980
 SOL01990
 SOL02000
 SOL02010
 SOL0202C
 SOL02030
 SOL02040
 SOL02050
 SOL02060
 SOL02070
 SOL02080
 SOL02090

SOL02110
 SOL02120
 SOL0213C
 SOL02140
 SOL02150
 SOL0216C
 SOL02170
 SOL02180
 SOL02190
 SOL02200
 SOL02210
 SOL02220
 SOL02230
 SOL0224C
 SOL02250
 SOL02260
 SOL02270
 SOL02280
 SOL0229C
 SOL02300
 SOL02310
 SOL02320
 SOL02330


```

C      *CCNDTU, DENSITY, DENSYC, DENSYS, RFOULC, RFOULS,
      *IDNUM, SEFFEC, TEMPCF, TEMPSF, CONDCF, CONDSF,
      *CCNOIL, CONELE, CONGAS, XMR
C      COMMON/FILES/NAME10, NAME11, NAME12, NAME13, XLAT,
      *TAMB(12), HDD(12), WIND(12), XI(12),
      *XMEANT, HDDTCT, XMEANW, XMEANI
C      DIMENSION QSUBI(12), QHLI(12), QDHWI(12),
      *DELTA(365), XOMEGA(365), SJOMEGA(365), POMEGA(365),
      *DDRAT(365), CIO(365), DIRRAT(12), XIO(12), XKT(12), DJFRAT(12),
      *SLOCOR(12), SUMDIR(12), SUMIO(12), ARGN(365), AFGD(365),
      *COEFF1(12), Y(12), Z(12), FBARI(12)
C      DATA PI/3.14159/
C      RLEG=180./PI
C      DRAD=PI/180.
C      GO TO (1000, 2000, 3000), ICALC
1000  CONTINUE
C      INPUT SECTION
C      OBTAIN DESIGN VARIABLE INITIAL VALUES
C      READ(5, 1001) AREAC, SLOPE, DIACTO, DIACTI, DIASTI,
      *VELOC, VELOS, HKLONG
C1001  FORMAT(8F9.4)
C      INITIALIZE CALENDAR ARRAY:
C      RETURN VIA COMMON/DAYS/
C      CALL SETCAL
C      INITIALIZE USER DEFINED OPTIONS/INPUTS:
C      RETURN VIA COMMON/FILE8/
C      CALL FILE08
C      DUCTAN=24.0*ULOSSR*AREAR
C      INITIALIZE CLIMATIC DATA:

```

```

SOL02340
SOL02350
SOL02360
SOL02370
SOL02380
SOL02390
SOL02400
SOL02410
SOL02420
SOL02430
SOL02440
SOL02450
SOL02460
SOL02470
SOL02480
SOL02490
SOL02500
SOL02510
SOL02520
SOL02530
SOL02540
SOL02550
SOL02560
SOL02570
SOL02580
SOL02590
SOL02600
SOL02610
SOL02620
SOL02630
SOL02640
SOL02650
SOL02660
SOL02670
SOL02680
SOL02690
SOL02700
SOL02710
SOL02720
SOL02730
SOL02740
SOL02750
SOL02760
SOL02770
SOL02780
SOL02790
SOL02800
SOL02810

```


SOL04260
SOL04270
SOL04280
SOL04290
SOL04300
SOL04310
SOL04320
SOL04330
SOL04340
SOL04350
SOL04360
SOL04370
SOL04380
SOL04390
SOL04400
SOL04410
SOL04420
SOL04430
SOL04440
SOL04450
SOL04460
SOL04470
SOL04480
SOL04490
SOL04500
SOL04510
SOL04520
SOL04530
SOL04540
SOL04550
SOL04560
SOL04570
SOL04580
SOL04590
SOL04600
SOL04610
SOL04620
SOL04630
SOL04640
SOL04650
SOL04660
SOL04670
SOL04680
SOL04690
SOL04700
SOL04710
SOL04720
SOL04730

COMPUTE MAJOR DEPENDENT DESIGN VARIABLE
COSTFU, 1ST YEAR FUEL COST (1/BTU)

CONOIL=142000.
CCNELE=3413.
CONGAS=100000.

IF(NFUEL.EQ.1)GO TO 523
IF(NFUEL.EQ.2)GO TO 524
CCSTFU=CCSTGAS/(CONGAS*EFFGAS)
GO TO 525
COSTFU=CSTOIL/(CONOIL*EFFOIL)
GO TO 525
COSTFU=CSTELE/(CONELE*EFFELE)
CCCONTINUE

COMPUTE MAJOR DEPENDENT DESIGN VARIABLE
SUMFC, TOTAL ANNUAL SOLAR ENERGY PROVIDED (BTU/YR)

DO 74 II=1,12
QSUBI(II)=0.0
SUMDIR(II)=0.0
SUMIO(II)=0.0
DIRRAT(II)=0.0
XIO(II)=0.0
XKT(II)=0.0
DIFRAT(II)=0.0
SUNCOR(II)=0.0
CCEFF(II)=0.0
Y(II)=0.0
Z(II)=0.0
FBARI(II)=0.0
CONTINUE

74
C

SOL04740
SOL04750
SOL04760
SOL04770
SOL04780
SOL04790
SOL04800
SOL04810
SOL04820
SOL04830
SOL04840
SOL04850
SOL04860
SOL04870
SOL04880
SOL04890
SOL04900
SOL04910
SOL04920
SOL04930
SOL04940
SOL04950
SOL04960
SOL04970
SOL04980
SOL04990
SOL05000
SOL05010
SOL05020
SOL05030
SOL05040
SOL05050
SOL05060
SOL05070
SOL05080
SOL05090
SOL05100
SOL05110
SOL05120
SOL05130
SOL05140
SOL05150
SOL05160
SOL05170
SOL05180
SOL05190
SOL05200
SOL05210

COMPUTE COLLECTOR/STORAGE FLOWRATE AND CAPACITANCE

ARECTO=PI*DIACTO*DIACTO/4.0
ARECTI=PI*DIACTI*DIACTI/4.0
AREAST=PI*(DIASTI*DIASTI-DIACTO*DIACTO)/4.0
FLOWC=DENSYS*ARECTI*VELOC
FLCWS=DENSYS*AREAST*VELOS
CAPAC=360C.*FLOWC*CSUBPC
CAPAS=3600.*FLOWS*CSURPS
GPMC=448.83*ARECTI*VELOC
GPMS=448.83*AREAST*VELOS
GFMCAR=GPMC/AREAC
GPMSAR=GPMS/AREAC

OBTAIN MINIMUM CAPACITANCE FOR COLLECTOR/STORAGE HEAT EXCHANGER

IF(CAPAC.LE.CAPAS) GO TO 19
CMIN=CAPAS
CMAX=CAPAC
GO TO 21
CMIN=CAPAC
CMAX=CAPAS
CONTINUE

COMPUTE COLLECTOR/STORAGE HEAT EXCHANGER COEFFICIENTS

VISI04=C.708E-05
PRI04=4.34
CND104=0.364
VIS176=0.392E-05
PRI76=2.22
CND176=0.387

REYNC=(VELOC*DIACTI)/VIS176
REYNS=(VELOS*(DIASTI-DIACTO))/VIS104

RSTAR=DIACTC/DIASTI

IF(REYNC.GE.2200.)GO TO 1025
HXFRI=(CND176/DIACTI)*(48.0/11.0)
GO TO 1026
HXFRI=(CND176/DIACTI)*0.023*(REYNC**0.8)*(PRI76**0.4)

1025


```

SUMDIR(I)=SUMDIR(I)+DDRAT(M)
SUMIO(I)=SUMIO(I)+DIO(M)
CONTINUE
DIRRAT(I)=SUMDIR(I)/XXX(I,1)
XIO(I)=SUMIC(I)/XXX(I,1)
XKT(I)=XI(I)/XIO(I)
DIFRAT(I)=1.3903-4.0273*XKT(I)+5.5315*XKT(I)*XKT(I)
      *-3.108*XKT(I)*XKT(I)*XKT(I)
*
SLOCOR(I)=(1.0-DIFRAT(I))*DIRRAT(I)+DIFRAT(I)
      *(1.0+COS(SLOPE*DRAD))*0.5+RHO*(1.0-COS(SLOPE*DRAD))*0.5
*
-----COMPUTE KLINE CORRELATION PARAMETERS
COEFF1(I)=FACHEX*AREAC*XXX(I,1)/QSUBI(I)
Y(I)=COEFF1(I)*FRTA*TARAT*X1(I)*SLOCOR(I)
Z(I)=COEFF1(I)*FRUL*24.*(212.-TAME(I))
*
-----COMPUTE MONTHLY LOAD FRACTIONS BASED ON KLINE CORRELATION
FBARI(I)=1.029*Y(I)-0.065*Z(I)-0.245*Y(I)*Y(I)+0.0018*Z(I)*Z(I)
      +0.0215*Y(I)*Y(I)*Y(I)
      IF(FBARI(I).GE.1.0)GO TO 255
      GC TO 256
FEARI(I)=1.0
CONTINUE
255
256
257
-----COMPUTE ANNUAL SOLAR ENERGY PROVIDED , SUMFQ
SUMHL=0.0
SUMDHW=0.0
SUMQ=0.0
SUMFQ=0.0
DO 825 I=1,12
SUMHL=SUMHL+QHLI(I)
SUMDHW=SUMDHW+QDHWI(I)
SUMQ=SUMQ+QSUBI(I)
SUMFQ=SUMFQ+FBARI(I)*QSUBI(I)
CONTINUE
825

```



3500

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C3501

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C3502

63


```

* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H APR ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H MAY ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H JUN ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3)

C
C
WRITE(6,3503) (XI(IR),HDD(IR),TAMB(IR),QHLL(IR),QDTHW(IR),
* ,XIO(IR),SLOCOR(IR),FBARI(IR),IR=7,12)
* ,HDDTOT,SUMHL,SUMDHH,FBAR

C
C
FORMAT(1H,
* ,T5,4H JUL ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H AUG ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H SEP ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H OCT ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H NOV ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,4H DEC ,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
* ,T77,F6.1,T89,F5.3,T100,F5.3,/
* ,T5,5HTOTAL,T25,F6.1,T48,E11.4,T61,E11.4,/
* ,T77,19H>>WEIGHTED AVERAGE,T100,F5.3)

C
WRITE(6,3504) JAREAC,CAPAC
* ,SLOPE,CAPAS
* ,DIAC1I,HXFRI
* ,DIAC1C,HXFRO
* ,DIAC1I,GPMC
* ,VELOC,GPCS
*
FCRMT(1H,T18
* ,28HDESIGN VARIABLES/CONSTRAINTS,T72,16HCTHER PARAMETERS,/
* ,T18,28H-----,T72,16H-----,
* ,T5,4OHCLECTOR AREA (FT*2) (BTU/HR F).....>>,F1C.2
* ,T5,4OHCLECTOR TILT CAPACITY (DEG) .....>>,E10.3,/
* ,T5,4OHCSTORAGE SIDE CAPACITY (BTU/HR F).....>>,F1C.2
* ,T5,4OHCLECTOR SIDE TUBE INNER DIA. (FT) .....>>,E10.3,/
* ,T5,4OHCLECTOR SIDE CONVECTION COEFF (FT) .....>>,F1C.4
* ,T5,4OHCLECTOR SIDE TUBE CUTER DIA. (FT) .....>>,F10.4
* ,T5,4OHCSTORAGE SIDE CONVECTION COEFFICIENT (FT) .....>>,F1C.4
* ,T5,4OHCSTORAGE SIDE TUBE (INCH) INNER DIA. (FT) .....>>,F10.4

```


SOL08100
SOL08110
SOL08120
SOL08130
SOL08140
SOL08150
SOL08160
SOL08170
SOL08180
SOL08190
SOL08200
SOL08210
SOL08220
SOL08230
SOL08240
SOL08250
SOL08260
SOL08270
SOL08280
SOL08290
SOL08300
SOL08310
SOL08320
SOL08330
SOL08340
SOL08350
SOL08360
SOL08370
SOL08380
SOL08390
SOL08400
SOL08410
SOL08420
SOL08430
SOL08440
SOL08450
SOL08460
SOL08470
SOL08480
SOL08490
SOL08500
SOL08510
SOL08520
SOL08530
SOL08540
SOL08550
SOL08560
SOL08570

```

*,T57,40HC COLLECTOR SIDE FLOW RATE (GPM) .....,F1C.4,/
,T5,40HC COLLECTOR SIDE FLOW VELOCITY (FT/SEC) .....,F10.4,/
,T57,40HC STORAGE SIDE FLOW RATE (GPM) .....,F10.4,/

```

* * *

C

```

WRITE(6,3505)VELO5,GPMC AR
,HX LONG,GPM SAR
,EFFECT
,G1,SUM FQ
,G2,SUM Q
,G3,FBAR
,G4,XNPV
,G5,UHEX I

```

* * *
* * *
* * *

C

```

FORMAT(1H
,T5,40HC STORAGE SIDE FLOW VELOCITY (FT/SEC) ..,F10.4
,T57,40HC NORMALIZED COLLECTOR FLOW (GPM/AREAC) .....,F10.4,/
,T5,40HC HEAT EXCHANGER LENGTH (FT) .....,F10.2
,T57,40HC NORMALIZED STORAGE FLOW (GPM/AREAC) .....,F1C.4,/
,T5,40HC .....,CON STRAINTS .....,F10.4/
,T57,40HC HEAT EXCHANGER EFFECTIVENESS .....,F10.4/
,T5,40HC HEX ANNULAR DIAMETER DIFFERENCE (FT) .....,F10.4
,T57,40HC SOLAR ENERGY DELIVERED (BTU/YEAR) .....,E10.3,/
,T5,40HC COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT) .....,F10.4
,T57,40HC TOTAL ENERGY DEMAND (BTU/YEAR) .....,E1C.3,/
,T5,40HC COLLECTOR SIDE REYNOLDS NUMBER .....,E10.3
,T57,40HC ANNUAL AVERAGE SOLAR LOAD FRACTION .....,F1C.4,/
,T5,40HC STORAGE SIDE REYNOLDS NUMBER .....,E10.3
,T57,40HC JECTIVE: NPV OF SOLAR INVESTMENT .....,E10.3,/
,T5,40HC CAPACITY RATIO (CMIN/CMAX) .....,F1C.4
,T57,40HC HEX CCEFFICIENT (BTU/HR F FT*2) .....,F10.2)

```

3505

C

```

WRITE(6,3506)G6,CCSTTC,G7,FPP

```

C

```

FCR MAT(1H
,T5,40HC FLOW PARAMETER Z2(GCF/FRUL) .....,F10.4
,T57,40HC TOTAL INSTALLATION COST ($) .....,F1C.2,/
,T5,40HC FLOW PARAMETER Z1(GCF/FRPUL) .....,F10.2
,T57,40HC COLLECTOR FLOW FACTOR(FPP) .....,F10.4)

```

3506

C

```

WRITE(6,3507)
FCR MAT(1H1,////,28H ERROR MESSAGES IF ANY FOLLOW)
RETURN
END

```

3507



```

RETURN
END

SUBROUTINE CMA11C

THIS FILE IS SET UP TO PROVIDE CLIMATOLOGICAL DATA FOR
THE 97 LOCATIONS DEFINED BY NOAA. INFORMATION INCLUDES
LATITUDE, (XLAT), ETC

COMMON/FILE89/LOCATE

COMMON/FILE9/NAM10,NAM11,NAM12,NAM13,XLAT,
* TAMB(12),HDD(12),WIND(12),X1(12),
* XMEANT,HDDTOT,XMEANW,XMEANI

DIMENSION LCCNM(20),NAME10(20),NAME11(20),NAME12(20),NAME13(20),
* XLAT(20),CLIMAT(20,12,4)

DO 900 LL=1,20
  READ(9,902)LOCNM(LL),NAME10(LL),NAME11(LL),NAME12(LL),NAME13(LL),
  * XLAT(LL)
  READ(9,903) ((CLIMAT(LL,1,K),I=1,12),K=1,4)
  CONTINUE

L=LOCATE
XLAT=XLAT(LL)
NAM10=NAME10(LL)
NAM11=NAME11(LL)
NAM12=NAME12(LL)
NAM13=NAME13(LL)

SUMT=0.0
SUMH=0.0
SUMW=0.0
SUMI=0.0
DO 901 I=1,12
  TAMB(I)=CLIMAT(LL,1,I)
  HDD(I)=CLIMAT(LL,1,I,2)
  WIND(I)=CLIMAT(LL,1,I,3)
  X1(I)=CLIMAT(LL,1,I,4)
  SUMT=SUMT+TAMB(I)
  SUMH=SUMH+HDD(I)

```

SOL09550
 SOL05560
 SOL09570
 SOL09580
 SOL09600
 SOL05610
 SOL09620
 SOL09630
 SOL05640
 SOL09650
 SOL09660
 SOL05670
 SOL09680
 SOL09690
 SOL09700
 SOL09710
 SOL09720
 SOL09730
 SOL09740
 SOL05750
 SOL09760
 SOL09770
 SOL05780
 SOL09790
 SOL09800
 SOL09810
 SOL09820
 SOL09830
 SOL05840
 SOL09850
 SOL05860
 SOL09870
 SOL09880
 SOL05890
 SOL09900
 SOL09910
 SOL05920
 SOL09930
 SOL09940
 SOL09950
 SOL09960
 SOL05970
 SOL09980
 SOL09990
 SOL10000
 SOL10010
 SOL10020

901	SUMW=SUMW+WIND(I)	SOL10030
C	SUM I=SUM I+XI(I)	SOL10040
	CCNT INUE	SOL10050
	X MEANT=SUMT/12.0	SOL10060
	HDDTOT=SUMH	SOL10070
	XMEANW=SUMW/12.0	SOL10080
	XMEANI=SUM I/12.0	SOL10090
902	FORMAT(14,4A4,F6.2)	SOL10100
903	FCR MAT(12F6.1)	SOL10110
	RETURN	SOL10120
	END	SOL10130
C		SOL10140
C		SOL10150
C		SOL10160
C		SOL10170
C		SOL10180
C		SOL10190
C		SOL10200
C		SOL10210
C		SOL10220
C		SOL10230



APPENDIX C

SOLOAD-1 Data Files

COPIES/CONMIN INPUT DATA: FILE FTC5F001
SOLAR ENERGY OPTIMIZATION ANALYSIS CR DESIGN

NCALC	2	NDV	8	NSV	0	N2VAR	C	IPNPUT	2	IPSENS	0	IPZVAR	0	NFDG	0
IPRINT	1	ITMAX	500	ICNDR	0	NSCAL	5	ITRM	0	LINCBJ	0	NACMX1	0		
FDCH	0.01	FDCHM	0.001	CT	-0.05	CTMIN	0.004	CTL	-0.01	CTLMIN	C.CC1	TFETA	1.0		
DELFUN	0.001	DABFUN	0.001	ALPHA X	0.1	ABOBJ1	0.1								
NDVTOT	0	IOBJ	9	SGNOBJ	+1.0										

DESIGN VARIABLE LIMITS: BOUNDS/INITIAL VALUE/SCALE FACTOR

V.LB	V.UB	X.	SCALE
------	------	----	-------

100.0	2000.0	400.0	(FT**2)
-------	--------	-------	---------

C.0	90.0	60.0	(DEGREES)
-----	------	------	-----------

.005	PRIMARY LOOP	OUTER DIAMETER	(FEET)
------	--------------	----------------	--------

.004	PRIMARY LOOP	INNER DIAMETER	(FEET)
------	--------------	----------------	--------

.05	STORAGE LOOP	HEX CASING INNER DIAMETER	(FEET)
-----	--------------	---------------------------	--------

1.0	PRIMARY LOOP	FLUID VELOCITY	(FT/SEC)
-----	--------------	----------------	----------

1.0	STORAGE LOOP	FLUID VELOCITY	(FT/SEC)
-----	--------------	----------------	----------

5.0	HEX LENGTH	(FEET)	
-----	------------	--------	--



DESIGN VARIABLE IDENTIFICATION

\$ \$ \$

NDSGN	IDSGN	A. MULT
1	1	1.0
2	2	1.0
3	3	1.0
4	4	1.0
5	5	1.0
6	6	1.0
7	7	1.0
8	8	1.0

\$ \$

NCONS
7

CONSTRAINT FUNCTION IDENTIFICATION AND BOUNDS

\$ \$ \$ \$ \$ \$

HEX ANNULAR THICKNESS (FEET)

10	1
0.005	10.0

\$ \$ PRIMARY LOOP DOUBLE THICKNESS (FEET)

11	1
0.005	0.01

\$ \$ PRIMARY LOOP REYNOLDS NUMBER (DIMENSIONLESS)

12	0
0.0	.49E 06

\$ \$ STORAGE LOOP REYNOLDS NUMBER (DIMENSIONLESS)

13	0
0.0	.50E 06

\$ \$ CAPACITY RATIO CMIN/CMAX (DIMENSIONLESS)

14	0
0.0001	0.999

\$ \$ FLOW PARAMETER Z2 (GCP/FRUL) (DIMENSIONLESS)

15	0
1.0	.10E 08

\$ \$ FLOW PARAMETER Z1 (GCP/FRPUL) (DIMENSIONLESS)

16	0
9.0	16.0

\$ \$ INITIAL VALUES TO BE READ IN FOLLOWEND

END

600.0	50.0	0.05	0.03	0.10	20.0	20.0	6.0
-------	------	------	------	------	------	------	-----

SCLOAD-1 SYSTEM USER DEFINED OPTICS: FILE FT08F001

THIS FILE IS CALLED BY THE SOLOAL-1 SYSTEM SUBROUTINE
FILE08 AND ALLOWS COMPLETE FLEXIBILITY FOR THE USER IN
CHOOSING VARIOUS PARAMETERS.

STUDY APPROACH: NAME1, NAME2(2A4); ENERGY COMPARISON: NAME3, NAME4(2A4)
ANALYSIS IS/DESIGN OIL/ELECTRIC/GAS

ANALYSIS OIL

LOGICAL INDEX(ANALYSIS): LANA(111); LOGICAL INDEX(DESIGN): LDES(111);
T/F

LOCATION INDEX: LOCATE(13); ENERGY INDEX: NFUEL(13)
1/2/3.../97 1=OIL/2=ELE/3=GAS

TF 1C 1

COLLECTOR MANUFACTURER: NAME5/6/7/8/9 (5A4);
INTERCEPT PARAMETER: FRTA(F9.4); SLOPE PARAMETER: FRUL(F9.4)

FEDERAL PRISON I. D .627 .883

TARAT RHO C SUBPC C SUBPS XLIFE DISCON FLATE
.93 .20 1.0 1.0 20. .0900 .1100

COSTCR COSTIN COSTTK OPTSTO COSTHX PUMPOW
5.4 10. 00.08 15.30 5.00 1.00

CSTOIL CSTELE CSTGAS EFFOIL EFFELE EFFGAS
.90 .05 .40 .70 .99 .70

ULOSSR AREAR DENTS USEH20 TEMH20 TEMGR
.05 5000. 6. 20. 140. 55.

CONDTC DENSYC DENSYD RFOULC RFOULS
220.0 60.81 62.05 0.001 0.001

IDNUM SEFFEC TEMPCF TEMPSF CONDCF CONDST
233 1.0 176.0 104.0 0.387 0.364

CENCIL CONELE CONGAS XMR
142000. 3413. 100000. .001

— 55 —

LINE 1 INCLUDES LOCATION NUMBER, CITY, STATE, AND LATITUDE

8.7

11.7	11.7	12.4	11.5	11.3	10.6	5.7	9.5	10.1	10.7	10.9	11.3
415.3	724.	1133.	214.	315	77.8	1757.4	1762.4	1500.6	1102.5	688.3	310.6
18	ADAK	34.7	37.1	40.3	44.1	48.4	50.7	47.8	42.4	37.4	34.2
33.8	32.8	940.3	836.8	765.2	628.3	514.9	443.0	516.6	701.5	828.0	953.9
967.5	509.5	15.3	14.8	13.6	11.6	11.2	12.4	13.2	14.8	15.4	14.4
14.4	14.6	716.4	1032.6	1179.6	1182.1	1120.4	948.6	759.3	528.2	307.9	187.2
231.2	432.5	ARIZONA	33.43								
19	PHEONIX	61.1	68.8	78.3	87.5	92.4	89.5	84.4	72.6	55.8	52.0
51.4	55.5	156.8	35.6	3.1	.0	.0	.0	.2	17.3	172.0	404.5
422.0	272.0	6.6	7.2	7.2	7.2	7.4	6.8	6.6	6.0	5.5	5.3
5.3	6.0	12354.9	2676.5	2739.2	2486.5	2292.7	2015.5	1576.5	150.5	932.0	
1021.3	1374.2	1814.1	2354.1	54.7	63.0	72.2	69.7	55.3	47.7	35.4	26.5
24.5	29.2	35.1	44.1	330.4	129.5	5.2	30.0	195.9	538.2	889.0	1193.6
1255.6	1014.9	926.6	626.5	10.6	10.5	9.3	9.2	9.3	9.3	10.4	10.4
11.1	11.1	11.6	12.0	10.6	10.5	9.3	9.2	9.3	9.3	10.4	10.4
539.2	881.8	1371.5	1820.3	2280.3	2479.8	2555.8	2239.4	1769.3	1203.2	688.7	477.1

APPENDIX D

EXPERIMENT REPORT SUMMARIES

Each optimization problem or experiment is represented by an input summary report and an output summary report. These reports are tied together by a unique identification as follows:

$$\begin{array}{ccccc} L & L & N_1 & N_2 & N_3 \\ - & - & \underline{\quad} & \underline{\quad} & \underline{\quad} \end{array}$$

where,

LL = location identification number in accordance with Appendix C

N_1 = present worth factor identification number

$$1 - F'_1 = 18.22$$

$$2 - F'_1 = 24.34$$

N_2 = collector identification number

1 - Solarnetics

2 - American Sun

3 - Federal Prison Institute Double Glaze

N_3 = heat load conductance

$$1 - UA = 30000 \text{ Btu/HDD}$$

$$2 - UA = 20000 \text{ Btu/HDD}$$

$$3 - UA = 10000 \text{ Btu/HDD}$$

The following report sets are included:

1111	2222	3111	4111
1112	2223	3112	4112
1113	2232	3213	4113
1213	2233	3222	4222
1223		3223	4223
1232		3232	4232
1233		3233	4233

9111	10111	11111	12111
9112	10112	11112	12112
9113	10112	11113	12113
9213	10213	11221	12221
9221	10221	11222	12222
9222	10222	11223	12223
9223	10223	11232	12232
9231	10231		
9232	10232		
	10233		

13111	14111	15111	16111
13112	14112	15112	16112
13223	14224	15223	16222
13232	14232	15232	16223
			16232


```
*****  
**          **      *   *   *   *   *   *   *   *   *   *  
**        S O L D A B - I  
*** SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  
-----  
**           DATA OPTIONS/INPUTS SUMMARY  
*****  
**     >>>DATA MATCH TO OUTPUT ID NO.  
**                               *****  
**                                INPUT  
**                              IMOD-1 LWK AUGUST 1979
```

ANALYSIS

STUDY APPROACH

COLLECTOR COLARNETICS

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LACRUSSE

LOCATION

ECONOMIC ESTIMATES

COLLECTOR TEST RESULTS,

1

LOCATION INDEX.....

SYSTEM LIFE (YEARS) ..	20.00
DISCOUNT RATE	0.1150
INFLATION RATE	0.1050

```

SLUPL:
PARAMETER,FRUL.... 1.0380
INTERCEPT:
PARAMETER,FRTA.... 0.6910
BASE COST,$/FT**2... 12.58

```

LACTUOSE, DEGREES.....	43.87
MEAN TEMPERATURE.....	46.12
INSOL(BTU/DAY FT**2)	1160.56
LOAD FACTOR, HDE.....	6531.55
MEAN GRUND TEMP.....	55.00

SELECTED PARAMETERS

ENERGY COMPARATIVE ESTIMATES

```
COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT**F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT**F).....
COLLECTOR SIDE FLOWING FACTOR(FR F/RTU).....
STORAGE SIDE FLOWING FACTOR(FR F/RTU).....
ESTIMATED TPTIMUM SURFACE(LB/AREAC).....
ESTIMATED GRINDING POWER(KPH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PREL.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST ($/F**2).....
ESTIMATED STORAGE TANK COST($/LR STOKED).....
ESTIMATED MAINTENANCE (% INSTALLED COST/YR).....
```

TYPE ENERGY BASE	EFFICIENCY	COST	HEATING VALUE
INDEX TYPE			
1 OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)
2 ELF	0.99	0.65 (\$/KWH)	3413.0 (BTU/KWH)
3 GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)

HEAT LOAD CAPACITIES
LOAD LOSS COEFFICIENT (BTU/HR-1-F*2)
LOAD SURFACE HEAT TRANSFER AREA (FT*2)
LOAD CONDUCTANCE (BTU/DEC-1-DAY)
DOMESTIC HOT WATER (GPM) DURING MP
ESTIMATED DAILY DHW USAGE (GAL/PER)
ESTIMATED DHW USERS (PER)
ESTIMATED SPACE THERMAL EFFECTIVENESS

176.60
60.81
1.0000
0.3870
104.03
62.09
1.0000
0.3240
0.0010
0.0010
220.09
15.30
0.20
1.0000
10.93
5.00
0.08
0.01

* * * * * S O L A R - 1
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 * * * * * RESULTS OF ANALYSIS FOR LACHOSSE WISC
 * * * * * >>>>DATA MATCH TO INPUT ID NO. 1111
 * * * * * QMCU-1 LMK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	BTU/DAY	EXTRA-TERRESTRIAL INSCLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FACTOR
	BTU/DAY FT**2	DLG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2			
JAN	481.3	1536.1	15.4	0.4608E 08	0.2637E 07	0.2637E 07	1088.7	1.841	0.017	
FEB	764.5	1253.1	20.7	0.3759E 08	0.2382E 07	0.2382E 07	1537.6	1.584	0.034	
MAR	1100.8	1055.6	31.0	0.3167E 08	0.2037E 07	0.2037E 07	2213.7	1.276	0.056	
APR	1426.2	546.8	47.0	0.1640E 08	0.2552E 07	0.2552E 07	2947.9	1.055	0.110	
MAY	1712.8	255.2	58.7	0.7056E 07	0.2637E 07	0.2637E 07	3507.0	0.934	0.235	
JUN	1905.5	42.3	68.5	0.1269E 07	0.2552E 07	0.2552E 07	3757.0	0.886	0.541	
JUL	1900.5	6.9	72.5	0.2070E 06	0.2637E 07	0.2637E 07	3641.9	0.908	0.701	
AUG	1666.3	19.1	70.4	0.5730E 06	0.2637E 07	0.2637E 07	3178.5	1.007	0.627	
SEP	1241.9	174.1	60.8	0.5223E 07	0.2552E 07	0.2552E 07	2486.2	1.186	0.252	
OCT	863.5	444.3	50.5	0.1333E 08	0.2637E 07	0.2637E 07	1751.0	1.468	0.106	
NOV	493.9	886.9	35.4	0.2661E 08	0.2552E 07	0.2552E 07	1153.5	1.713	0.028	
DEC	331.2	331.2	22.1	0.9966E 07	0.2637E 07	0.2637E 07	959.2	1.856	0.035	
TOTAL	6531.6			0.1959E 05	0.3105E 08	0.3105E 08		AVERAGE	0.086	

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	COLLECTOR TILT ANGLE (DEG)	COLLECTOR TUBE INNER DIA. (FT)	COLLECTOR TUBE OUTER DIA. (FT)	COLLECTOR TUBE THICK (IN)	COLLECTOR TUBE LENGTH (FT)	COLLECTOR TUBE WEIGHT (LBS)	COLLECTOR TUBE COST (\$)	COLLECTOR TUBE EFFICIENCY (%)	COLLECTOR TUBE FACTOR	COLLECTOR TUBE FACTOR
481.3	15.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
764.5	20.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1100.8	31.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1426.2	47.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1712.8	58.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1905.5	68.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1900.5	72.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1666.3	70.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1241.9	60.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
863.5	50.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
493.9	35.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
331.2	22.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6531.6		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

DESIGN DATA CATEGORIES/INPUTS SUMMARY

>>>>DATA MARCH TO OUTPUT 10 HC. 1112
 1M10-1 LWK AUGUST 1979

[illegible]

ENERGY COMPARATIVE ESTIMATES.

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE
1	CHL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)
2	ELE	0.99	0.65 (\$/KWH)	3413.0 (BTU/KWH)
3	ELE	0.70	0.400 (\$/TUM)	100000.0 (BTU/TUM)

HEAT LOCAL CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F.FT**2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5009.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	20399.99
HEATING WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	20.00
ESTIMATED DHW USES (PER) ..	0.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS ..	1.00

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FLOWING FACTOR(HR F/RTU)
STORAGE SIDE FLOWING FACTOR(HR F/RTU)
HEX TUB CONDUCTIVITY(BTU/HR*FT).....
ESTIMATED OPTIMUM STORAGE(LB/AREA).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREA).....
ESTIMATED CORRECTION FOR TAN ALPHA PED.
ESTIMATE) INSTALL/LABCK COST ($/AREA).....
ESTIMATED HLX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LP STORED)
MAINTENANCE (% INSTALLED COST/YR).....

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STUDY APPROACH

ECONOMIC ESTIMATES-----
SYSTEM LIFE(YEARS).....
DISCOUNT RATE.....
INFLATION RATE.....

ANALYSIS

176.00
60.81
1.0000
0.2870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
0.93
15.00
0.08
0.01

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR LACRESSE WISC

>>>>DATA MATCH TO INPUT ID NO. 1112
OMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREES DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.3	1536.1	15.4	0.3134E 08	0.2637E 07	1088.7	1.846	0.024
FEB	764.5	1253.1	20.7	0.2550E 08	0.2382E 07	1537.6	1.587	0.048
MAR	1100.8	1055.6	31.0	0.2153E 08	0.2637E 07	2213.7	1.277	0.078
APR	1426.8	846.8	47.0	0.1115E 08	0.2552E 07	2947.9	1.054	0.149
MAY	1712.8	635.2	58.7	0.4798E 07	0.2637E 07	3507.0	0.932	0.257
JUN	1505.5	42.3	68.5	0.8629E 06	0.2552E 07	3757.0	0.884	0.587
JUL	1900.5	6.9	72.5	0.1408E 06	0.2637E 07	3641.9	0.906	0.710
AUG	1666.3	19.1	70.4	0.3896E 06	0.2637E 07	3178.5	1.005	0.652
SEP	1241.9	174.1	60.8	0.3552E 07	0.2552E 07	2486.2	1.185	0.312
OCT	863.5	444.3	50.9	0.9064E 07	0.2637E 07	1751.0	1.470	0.143
NOV	493.9	886.9	35.4	0.1809E 08	0.2552E 07	1153.5	1.716	0.035
DEC	369.5	331.2	22.1	0.6756E 07	0.2637E 07	959.2	1.861	0.048
TOTAL		6531.6		0.1332E 09	0.3105E 08		AVERAGE	0.116

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
	(FT**2)		
COLLECTOR AREA	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.988E 03
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR F)	0.512E 05
COLLECTOR TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFF.	1650.4468
COLLECTOR TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFFICIENT	4009.2195
STORAGE SIDE TUBE (HEX) INNER DIA. (FT)	>>>	COLLECTOR SIDE FLOW RATE (GPM)	2.0262
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	STORAGE SIDE FLOW RATE (CPM)	102.7698
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0203
HEAT EXCHANGER LENGTH (FT)	>>>	NORMALIZED STORAGE FLOW (GPM/AREAC)	1.0277
HEAT EXCHANGER DIAMETER (FT)	>>>	HEAT EXCHANGER EFFECTIVENESS	0.9438
HEX ANNULAR DIAMETER DIFFERENCE (FT)	>>>	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.191E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	>>>	TOTAL ENERGY DEMAND (BTU/YEAR)	0.164E 05
COLLECTOR SIDE REYNOLDS NUMBER	>>>	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1161
STORAGE SIDE REYNOLDS NUMBER	>>>	OBJECTIVE: NPV OF SOLAR INVESTMENT	>>>
CAPACITY RATIO (GAIN/CMAX)	>>>	HEX COEFFICIENT (BTU/HR F FT**2)	0.147E 03
FLOW PARAMETER Z1 (GCP/FRUL)	>>>	TOTAL INSTALLATION COST (\$)	354.45
FLOW PARAMETER Z1 (GCP/FRUL)	>>>	COLLECTOR FLOW FACTOR (FPP)	1000.53
			0.9465

RESULTS OF ANALYSIS FOR LACROSSE

>>>>DATA MAR CH TC INPUS ID NO. 1113
UMOD-1 LWK AUGUST 1979

DESIGN VARIABLES/CONSTRAINTS

SULLAD-1

STRUCTURAL OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTION'S/INPLIS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NC. 1213
IMOD-1 LNK AUGUST 1979

ANALYSIS

ENERGY COMPARATIVE ESTIMATES

INDEX	FUELED TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELE	0.99	0.65 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THER)	100000.0 (BTU/THER)	

HEAT LEAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.09
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	10799.00
DOMESTIC HOT WATER (DHW) DESIGN TEMP ..	140.00
ESTIMATED DAILY DHW USE/EAL (GAL/PER) ..	20.00
ESTIMATED DHW USERS (PER) ..	9.00
ESTIMATED SCWAGE T (L/D) ..	1.00

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(HR F/BTU).....
STORAGE SIDE FOULING FACTOR(HR F/BTU).....
HEX TURB CONDUCTIVITY(BTU/HR*F).....
ESTIMATED OPTIMUM STCFACE(LF/AREAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PRFD.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LB STCPED).....
ESTIMATED MAINTENANCE ($ INSTALLED COST/YR).....

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SELECTED PARAMETERS

116.00
50.81
1.0000
0.3870
134.00
62.09
1.0000
0.3640
0.0010
0.0010
222.00
15.30
0.20
1.0000
10.93
15.00
0.38
0.00

SUNDAY - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR LACROSSE WISC

 >>>>>DATA MATCH TC INPUT ID NO. 1213
 JMOD-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSULATION		HEATING DEGREE DAYS	AMBIENT TEMPERATURE DEG F	HEATING LOAD BTU/MONTH	DHW LOAD BTU/MONTH	EXTRA-TERRRESTRIAL INSULATION		COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY	FT**2					BTU/DAY	FT**2		
JAN	481.3		1536.1	15.4	0.1659E	08	0.2637E	07	1.868	0.070
FEB	764.5		1253.1	20.7	0.1353E	08	0.2382E	07	1.611	0.132
MAR	1100.8		1055.6	31.0	0.1140E	08	0.22637E	07	1.280	0.204
APR	1426.2		846.8	47.0	0.5905E	07	0.2552E	07	1.043	0.344
MAY	1712.8		235.2	58.7	0.2540E	07	0.2637E	07	0.915	0.525
JUN	1505.5		42.3	68.5	0.4568E	06	0.2552E	07	0.864	0.825
JUL	1900.5		6.9	72.5	0.7452E	05	0.2637E	07	0.899	0.899
AUG	1666.3		19.1	69.8	0.2063E	06	0.2637E	07	0.951	0.866
SEP	1241.9		174.1	70.4	0.1880E	07	0.2552E	07	1.185	0.579
OCT	803.5		444.3	50.5	0.4798E	07	0.2637E	07	1.486	0.331
NOV	493.5		886.9	35.4	0.9579E	07	0.2552E	07	1.751	0.106
DEC	309.5		331.2	22.1	0.3577E	07	0.2637E	07	1.906	0.120
TOTAL	6531.6				0.7054E	08	0.3105E	08		

DESIGI VQIABLES/CONSTRAINTS

COLLECTOR AREA	(FT**2)	159.72	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.160E 04
COLLECTOR TILT	(DEG)	42.11	STORAGE SIDE CAPACITY (BTU/HR F)	0.352E 05
COLLECTOR SIDE TUBE INNER DIA.	(FT)	0.0393	COLLECTOR SIDE CONVECTION COEFF.	589.3655
COLLECTOR SIDE TUBE OUTER DIA.	(FT)	0.0677	STORAGE SIDE CONVECTION COEFFICIENT	3574.7625
STORAGE SIDE TUBE(HEX) INNER DIA.	(FT)	0.1248	COLLECTOR SIDE FLOW RATE (GPM)	3.2620
STORAGE SIDE TUBE FLOW VELOCITY (FT/SEC)		2.5355	STORAGE SIDE FLOW RATE (GPM)	70.6953
COLLECTOR SIDE FLOW VELOCITY (FT/SEC)		18.2553	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0205
HEAT EXCHANGER LENGTH (FT)		70.43	NORMALIZED STORAGE FLOW (GPM/AREAC)	0.4426
HEAT EXCHANGER LENTH (FT)		70.43	HEAT EXCHANGE EFFECITVENESS	0.5150
HEX ANNUAL DIAMETER DIFFERENCE (FT)		0.0571	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.266E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)		0.0034	TOTAL ENERGY DEMAND (BTU/YEAR)	0.102E 09
COLLECTOR SIDE TUBE(HEX) THICKNESS		0.399E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2616
STORAGE SIDE REYNOLDS NUMBER		0.147E 06	OBJECTIVE: MPV OF SOLAR INVESTMENT	0.164E 04
STORAGE SIDE REYNOLDS NUMBER		0.0453	HEX COEFFICIENT (BTU/HR F FT**2)	3051.48
CAPACITY RATE (CMH/CMH)		9.6264	TOTAL INSTALLATION COST (\$)	3931.48
FLOW PARAMETER Z2(GC/F/IN)		9.12	COLLECTOR FLOW FACTOR(FPP)	0.5471
FLOW PARAMETER Z1(GC/F/IN)		9.12		

RESULTS OF ANALYSIS FOR LACROSSE WISC

>>>>DATA MATCH TO INPUT ID NO. 1223
OMCD-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	DHW LOAD	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	BTU/DAY	FT**2	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY	FT**2	DEG DAY	DEG F	BTU/MONTH		BTU/MONTH					
JAN	481.3	1536.1	15.4	0.1659E	08	0.2637E	07	1088.7			1.916	0.084
FEB	764.5	1253.1	20.7	0.1353E	08	0.2382E	07	1537.6			1.627	0.162
MAR	1100.3	1055.6	31.0	0.1140E	08	0.2637E	07	2213.7			1.281	0.248
APR	1426.2	846.8	47.0	0.5905E	07	0.2552E	07	2947.9			1.033	0.408
MAY	1712.8	635.2	58.7	0.2540E	07	0.2637E	07	3507.0			0.900	0.645
JUN	1905.5	422.3	63.5	0.4508E	06	0.2552E	07	3757.0			0.847	0.884
JUL	1900.5	26.9	72.5	0.7452E	05	0.2637E	07	3641.5			0.871	0.919
AUG	1660.3	19.1	70.4	0.2063E	06	0.2637E	07	3178.5			0.980	0.919
SEP	1241.9	174.1	60.8	0.1830E	07	0.2552E	07	2486.2			1.179	0.664
OCT	803.5	444.5	50.5	0.4798E	07	0.2637E	07	1751.0			1.496	0.398
NOV	495.9	386.9	35.4	0.9579E	07	0.2552E	07	1193.9			1.773	0.128
DEC	369.5	331.2	22.1	0.3577E	07	0.2637E	07	959.2			1.935	0.140
TOTAL		6531.6		0.7054E	08	0.3109E	08					

DESIGN VARIABLES/CONSTRAINTS

[illegible]

S O L U A D - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIMIZATION/INPUTS SUMMARY

>>>>> DATA MATCH T1 INPUT ID NO. 1233
IMCD-1 LMK AUGUST 1979

LOCATION	LACROSSE	WFC	COLLECTOR FEDERAL PRISON I. D.	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....	1			ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....	43.87				
MEAN TEMPERATURE.....	46.12		0.8830		
INSL (BTU/CLAY FT*2)	1160.56			SYSTEM LIFE (YEARS)...	20.00
LOAD FACTOR (H).....	6531.59		0.6270	DISCOUNT RATE.....	0.0900
MEAN GROUND TEMP.....	55.00		9.40	INFLATION RATE.....	0.1100

COLLECTOR TEST RESULTS,

SLOPE:
PARAMETER, PRUL..... 0.8830
INTERCEPT:
PARAMETER, FRTA..... 0.6270
BASE COST, \$/FT*2.... 9.40

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.50 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR FT*2)...	0.09
LOAD SURFACE HEAT TRANSFER AREA (FT*2)...	5000.00
LOAD CONDUCTANCE (BTU/CLAY DAY).....	10799.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW LOADS (PER).....	6.00
ESTIMATED SURFACE IF LOAD EFFICIENCIES...	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.....	176.0
COLLECTOR FLUID DENSITY (LB/FT*2).....	60.8
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)...	1.000
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F)	0.287
STORAGE FLUID MEAN TEMPERATURE.....	104.0
STORAGE FLUID DENSITY (LB/FT*3).....	62.0
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)...	1.000
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F)...	0.364
COLLECTOR SIDE FOULING FACTOR (HR*F/HR)...	0.001
STORAGE SIDE FOULING FACTOR (HR*F/HR)...	220.0
HEX TUBE CONDUCTIVITY (BTU/HR*FT*F).....	15.3
ESTIMATED OPTIMUM STORAGE (LB/AREAC)	0.2
ESTIMATED GROUND REFLECTANCE.....	1.000
ESTIMATED PUMPING POWER (KWH/AREAC).....	0.5
ESTIMATED CORRECTION FOR TAU ALPHA PRFD.	10.0
ESTIMATED INSTALL/LABOR COST (\$/AREAC)...	5.0
ESTIMATED HEX COST (\$/FT*2).....	0.0
ESTIMATED STORAGE TANK COST (\$/LB STORED)	0.001
MAINTENANCE (% INSTALLED COST/YR).....	

>>>>DATA MATCH TO INPUT ID NO. 1233
MTC-1 LMK AUGUST 1979

89

S-1-1-1

SOIL AND ENERGY OPTIMIZATION ANALYSIS FOR DESIGN

RESULTS OF ANALYSIS FOR FACTORS

>>>>DATA MAJCT TC INPJL ID NC 1252
INJD-I LNK AUGUST 1979

CHAP. PARAMETERS
>>> WEIGHTED AVERAGING

DE: 161 V F J 3 LF, COMB TRAITTS

S J L O A O - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN

RESULTS OF ANALYSIS FOR SHERIDAN WYOMING

>>>>DATA MATCH TO INPUT TO NO. 2222
OMOD-1 LMK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2	EXTRA- TERRRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
JAN	517.5	1364.0	21.0	0.2733E	08	0.2637E	07	1042.0			2.127	0.166
FEB	783.3	1083.0	26.7	0.2209E	08	0.2382E	07	1452.4			1.722	0.261
MAR	1204.8	1012.0	32.4	0.2064E	08	0.2637E	07	2175.8			1.324	0.373
APR	1537.2	661.4	43.0	0.1349E	08	0.2552E	07	2923.7			1.023	0.491
MAY	1882.7	359.7	53.6	0.7338E	07	0.2637E	07	3457.7			0.868	0.730
JUN	2156.0	127.6	62.6	0.2603E	07	0.2552E	07	3755.8			0.807	0.967
JUL	2325.0	47.3	70.8	0.3525E	06	0.2637E	07	3656.8			0.833	1.000
AUG	2005.0	34.3	69.5	0.6997E	06	0.2637E	07	3159.9			0.967	1.000
SEP	1502.0	241.8	57.8	0.4933E	07	0.2552E	07	2452.5			1.222	0.963
OCT	1075.5	562.0	46.5	0.1146E	08	0.2637E	07	1707.5			1.620	0.578
NOV	591.0	573.0	32.6	0.1785E	08	0.2552E	07	1147.3			2.030	0.255
DEC	441.4	1230.8	25.3	0.2511E	08	0.2637E	07	912.6			2.279	0.157
TOTAL		7666.9		0.1554E	05	0.3105E	08					0.382

>>>WEIGHTED AVERAGE

OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HF)	F)	0.490E 04
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HF)	F)	0.680E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFF.		1165.5313
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFFICIENT		4105.9375
STORAGE SIDE TUBE (INCH)	10.0	COLLECTOR SIDE FLOW RATE (GPM)		10.0486
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	3.5352	STORAGE SIDE FLOW RATE (GPM)		176.6272
STORAGE SIDE FLUID VELOCITY (FT/SEC)	23.2528	NORMALIZED COLLECTOR FLOW (GPM/AREA)		0.0203
HEAT EXCHANGER LENGTH (FT)	140.99	NORMALIZED STORAGE FLOW (GPM/AREA)		0.3561
HEAT EXCHANGER EFFICIENCY	0.0794	HEAT EXCHANGER EFFECTIVENESS		0.9135
HEX ANNUAL DIAMETER - DIFFERENCE (FT)	0.0058	SOLAR ENERGY DELIVERED (BTU/YEAR)		0.716E 03
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	0.317E 05	PEAK ENERGY DEMAND (BTU/YEAR)		0.187E 05
COLLECTOR SIDE FLOW NO. IMPR.	0.261E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION		0.3320
STORAGE SIDE REYNOLDS NUMBER	0.0557	OBJECTIVE: IMPV OF SOLAR INVESTMENT	>>>	0.594E 04
CAPACITY RATE (GALL/HR)	9.5092	HEX COEFFICIENT (BTU/HR FT**2)		322.97
FLOW PARAMETER Z2 (GPM/HR)	9.5092	TOTAL INSTALLATION COST (\$)		1014.31
FLOW PARAMETER Z1 (GPM/HR)	9.5092	COLLECTOR FLOW FACTOR(FPP)		0.5464

STRUCTURAL ENERGY OPTIMIZATION ANALYSIS FOR DESIGN

DESIGN DATA UPDATING/INPUTS SUMMARY

>>>>DATA MATCH PD OUTPUT ID NC. 2223
IMCD-I LK AUGUST 1979

LOCATION	SERIAL NO	WYTHING	COLLECTOR	AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX	2		COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATES	
ELEVATION	44.67		SLOPE			
TEMPERATURE	45.18		PARAMETER, FRUL	1.0390	SYSTEM LIFE (YEARS)	20.00
INSOL (BTU/CAY	1330.10		INTECEPT		DISCOUNT RATE	0.0900
LOAD FACTOR, HDO	7666.88		PARAMETER, FRFA	0.0380	INFLATION RATE	0.1100
LOAD FACTOR, TEMP	55.00		RASE COST \$/FT**2	6.55		

ENERGY COMPARATIVE ESTIMATES

INDEX	TYPE	EFFICIENCY	CFT	HEAT INC	VALUE
1	OIL	0.70	0.50 (\$/GAL)	142000.0	(BTU/GAL)
2	ELE	0.99	0.05 (\$/KWH)	3413.0	(BTU/KWH)
3	GAS	0.70	1.40 (\$/THERM)	100000.0	(BTU/THERM)

HEAVY LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR-F-T**2) ..	0.05
LOAD SURFACE HEAT TRANSFER AREA (F**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG-F) ..	10799.99
DOMESTIC HOT WATER (GAL) ..	140.00
ESTIMATED DAILY DHW USE (GAL/PER) ..	20.00
ESTIMATED CATHODES (GAL) ..	6.00
ESTIMATED STORAGE TO LEAD EFFECTIVENESS ..	1.00

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(RTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(RTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(RTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(RTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(F/F/PTU).....
STORAGE SIDE FOULING FACTOR(HR*F/BTU).....
HEX TUBE CONDUCTIVITY(RTU/HR*FT).....
ESTIMATED OPTIMUM STORAGE(LB/AREAC).....
ESTIMATED GROUPED REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAL ALPHA PREC.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST (LB/FT**2).....
ESTIMATED STORAGE TANK COST(LB/STARED).....
ESTIMATED MAINTENANCE COST(INSTALL COST/YR).....

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STUDY APPROACH		ECONOMIC ESTIMATES		ANALYSIS	
SYSTEM	LIFEL(YEARS)...			20.00	
DISCOUNT	RATE.....			0.0900	
INFLATION	RATE.....			0.1100	

SYSTEM LIFE (YEARS) ..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE	0.1100

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(RTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(RTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(RTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(RTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(F/F/PTU).....
STORAGE SIDE FOULING FACTOR(HR*F/BTU).....
HEX TUBE CONDUCTIVITY(RTU/HR*FT).....
ESTIMATED OPTIMUM STORAGE(LB/AREAC).....
ESTIMATED GROUPED REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAL ALPHA PREC.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST (LB/FT**2).....
ESTIMATED STORAGE TANK COST(LB/STARED).....
ESTIMATED MAINTENANCE COST(INSTALL COST/YR).....

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G O L D - I

SOLAR ENERGY OPTIMIZATION ANALYSIS TO DESIGN

--RESULTS OF ANALYSIS FOR SHERIDAN WYING--

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>>>>DATA MATCH TO INPUT ID NO. 2223

MOD-1 LWK AUGUST 1979

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MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AIR-TEMPERATURE	HEATING LOAD	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/EAF FT**2	DEG DAY	DEG F	BTU/TOOTH	BTU/MONTH	BTU/DAY FT**2		
JAN	517.5	1364.0	21.0	0.1473E 08	0.2637E 07	1042.0	2.124	0.178
FEB	788.3	1083.0	26.7	0.1170E 08	0.2382E 07	1492.4	1.720	0.277
MAR	1204.8	1012.0	32.4	0.1093E 08	0.2637E 07	2175.8	1.324	0.391
APR	1537.2	661.4	43.0	0.7143E 07	0.2552E 07	2523.7	1.024	0.459
MAY	1882.7	355.7	53.6	0.3885E 07	0.2637E 07	3497.7	0.870	0.707
JUN	2156.0	127.6	62.6	0.1376E 07	0.2552E 07	3755.8	0.808	0.927
JUL	2229.0	17.3	70.8	0.1868E 06	0.2637E 07	3636.8	0.835	1.000
AUG	2006.0	34.3	69.5	0.3704E 06	0.2637E 07	3159.9	0.969	1.000
SEP	1502.0	241.8	57.8	0.2611E 07	0.2552E 07	2452.5	1.222	0.866
OCT	1005.3	562.0	46.5	0.6070E 07	0.2637E 07	1707.5	1.819	0.577
NOV	591.0	913.0	32.6	0.1051E 08	0.2552E 07	1147.3	2.028	0.267
DEC	1230.8	1230.8	25.3	0.1323E 08	0.2637E 07	912.6	2.277	0.167
TOTAL	441.4	7666.9		0.8280E 08	0.3105E 08	>>>WEIGHTED	AVERAGE	0.411

DESIGN VARIABLE / CONSTRAINT		OTHER PARAMETERS		>>>WEIGHTED AVERAGE		0.411	
COLLECTOR AREA	(FT**2)	308.46	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.311E 04			
COLLECTOR TILT	ANGLE (DEG)	30.06	STORAGE SIDE CAPACITY (BTU/HR F)	0.447E 05			
COLLECTOR SIDE TUBE	INNER DIA. (FT)	0.0759	COLLECTOR SIDE CONVECTION COEFF.	1064.3394			
COLLECTOR SIDE TUBE	CUTTER DIA. (FT)	0.0809	STORAGE SIDE CONVECTION COEFFICIENT	3666.0127			
STORAGE SIDE TUBE	INNER DIA. (FT)	0.1408	COLLECTOR SIDE FLOW RATE (GPM)	6.3359			
COLLECTOR SIDE TUBE	FLUID VELOCITY (FT/SEC)	3.1431	STORAGE SIDE FLOW RATE (GPM)	89.6845			
STORAGE SIDE TUBE	FLUID VELOCITY (FT/SEC)	19.1529	NORMALIZED COLLECTOR FLOW (GPM/AREA(C))	0.0207			
HEAT EXCHANGER LEG F (FT)		79.96	NORMALIZED STORAGE FLOW (GPM/AREA(C))	0.2908			
HEAT EXCHANGER LEG G (FT)		79.96	HEAT EXCHANGER EFFECTIVENESS	0.8422			
HEAT EXCHANGER LEG H (FT)		79.96	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.468E 08			
HEAT EXCHANGER LEG I (FT)		79.96	TOTAL ENERGY DEMAND (BTU/YEAR)	0.114E 05			
HEAT EXCHANGER LEG J (FT)		79.96	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4115			
HEAT EXCHANGER LEG K (FT)		79.96	OBJECTIVE : NPV OF SOLAR INVESTMENT	0.423E 04			
HEAT EXCHANGER LEG L (FT)		79.96	HEX COEFFICIENT (BTU/FP F FT**2)	313.56			
HEAT EXCHANGER LEG M (FT)		79.96	TOTAL INSTALLATION COST (\$)	5577.83			
HEAT EXCHANGER LEG N (FT)		79.96	COLLECTOR FLOW FACTOR(FPP)	0.9476			

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DESIGN DATA OPTIMIZATION

>>>>DATA MATCH TO NC. 2232
FACD-1 LUK AUGUST 1979

ANALYSIS

SELECTED PARAMETERS

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COLLECTOR FLOW MEAN TEMPERATURE (L/R/FT**2).....
COLLECTOR FLOW DENSITY (L/R/FT**2).....
COLLECTOR FLOW SPECIFIC HEAT (BTU/L R**F).....
COLLECTOR FLOW CONDUCTIVITY (BTU/HR**F**F).....
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY (LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT (BTU/LB**F).....
STORAGE FLOW CONDUCTIVITY (BTU/FF FT**F).....
COLLECTOR SIDE FILLING FACTOR (HR F/BTU).....
STORAGE SIDE FILLING FACTOR (HR F/BTU).....
HEX TUBE CONDUCTIVITY (BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE (LB/AREAC).....
ESTIMATED GROUP R EL ECTANCE.....
ESTIMATED PUMPING POWER (KW/A F I AC).....
ESTIMATED CORRECTION FOR TAU ALPHA DEF.....
ESTIMATED INSTANT/ARCH CEST (4/AREAC).....
ESTIMATED HEAT COST (4/FT**2).....
ESTIMATED STORAGE TASK COST (4/LB STGE F).....
ESTIMATED STORAGE INSTALLED COST/YR.....

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LOAD LOSS COEFFICIENT (BTU/H F T**2) F T**2)
LOAD SURFACE HEAT TRANSFER AREA (F T**2) F T**2)
LOAD CONTACT ANGLE (R/DI/DIG) ONLY)
LOAD CONTACT ANGLE (R/DI/DIG) ONLY)
DOMESTIC HOT WATER (LBS) DESIGN TEMP.
ESTIMATED DAILY DRY WEIGHT (GAL/PER)
ESTIMATED DRY WEIGHT (GAL/PER)
ESTIMATED STORAGE CAPACITY (GAL)
ESTIMATED STORAGE CAPACITY (GAL)

$$\begin{array}{r} 0.17 \\ 5000.00 \\ 20399.99 \\ 140.00 \\ 20.00 \\ 6.00 \\ 1.00 \end{array}$$

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COLLECTOR FLOW MEAN TEMPERATURE (L/R/FT**2).....
COLLECTOR FLOW DENSITY (L/R/FT**2).....
COLLECTOR FLOW SPECIFIC HEAT (BTU/LR*F).....
COLLECTOR FLOW CONDUCTIVITY (BTU/HR*FT*F).....
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY (LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT (BTU/LB*F).....
STORAGE FLOW CONDUCTIVITY (BTU/FF FT*F).....
COLLECTOR SIDE FILLING FACTOR (HP F/RTU)
STORAGE SIDE FILLING FACTOR (HP F/BTU)
CONDUCTIVITY (BTU/HR FT F).....
OPTIMUM STORAGE (LB/AA*AC).....
GROUPED RESISTANCE.....
PUMPING POWER (KW/AF*AC).....
CORRECTION FOR TAU ALPHA DEF.....
INSTALLED COST (4/FT**2) (4/AA*AC).....
INSTALLED HEAT COST (4/FT**2) (4/LB STGE F)
INSTALLED STORAGE COST (4/INSTALLED COST/YR).....

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COLLECTOR FLOW MEAN TEMPERATURE (L/R/FT**2).....
COLLECTOR FLOW DENSITY (L/R/FT**2).....
COLLECTOR FLOW SPECIFIC HEAT (BTU/LR*F).....
COLLECTOR FLOW CONDUCTIVITY (BTU/HR*FT*F).....
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY (LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT (BTU/LB*F).....
STORAGE FLOW CONDUCTIVITY (BTU/FF FT*F).....
COLLECTOR SIDE FILLING FACTOR (HP F/RTU)
STORAGE SIDE FILLING FACTOR (HP F/BTU)
CONDUCTIVITY (BTU/HR FT F).....
OPTIMUM STORAGE (LB/AA*AC).....
GROUPED RESISTANCE.....
PUMPING POWER (KW/AF*AC).....
CORRECTION FOR TAU ALPHA DEF.....
INSTALLED COST (4/FT**2) (4/AA*AC).....
INSTALLED HEAT COST (4/FT**2) (4/LB STGE F)
INSTALLED STORAGE COST (4/INSTALLED COST/YR).....

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*****          S U B P R O G R A M - 1
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***** SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
***** ----- RESULTS OF ANALYSIS FOR SUBOPTIMUM
*****
*****          >>> DATA ACQUISITION INPUT TO PRO-2252
*****          MOD-1 LEW AUGUST 1979

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SOLUAD - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SHEPARD WYOMING

>>>>DATA WATCH
 T1 INPUT 10 NOV 2233
 QMCC-I LMK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSCLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FACTOR
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	517.5	1264.0	21.0	0.1473E 08	0.2637E 07	1042.0	2.115	0.178
FEB	788.5	1083.0	26.7	0.1170E 08	0.2332E 07	1452.4	1.716	0.270
MAR	1204.8	1012.0	32.4	0.1093E 08	0.2537E 07	2175.8	1.325	0.375
APR	1537.2	661.4	43.0	0.7143E 07	0.2552E 07	2923.7	1.029	0.488
MAY	1832.7	359.7	53.6	0.5851E 07	0.2637E 07	3457.7	0.876	0.701
JUN	2156.0	127.6	62.6	0.1373E 07	0.2552E 07	3755.8	0.815	0.942
JUL	2329.0	17.3	70.8	0.1868E 06	0.2637E 07	3636.8	0.841	1.005
AUG	2006.0	34.5	69.5	0.3704E 06	0.2637E 07	3155.5	0.974	1.000
SEP	1502.0	241.8	57.8	0.2611E 07	0.2552E 07	2452.5	1.225	0.864
OCT	1006.0	562.0	46.9	0.6070E 07	0.2637E 07	1707.5	1.617	0.563
NOV	591.0	573.0	35.6	0.1151E 08	0.2552E 07	1147.3	2.020	0.263
DEC	441.4	1230.8	25.3	0.1329E 08	0.2637E 07	912.6	2.265	0.169
TOTAL		7666.9		0.8280E 08	0.3105E 08			0.407

>>>WEIGHTED AVERAGE
 OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR TILT ANGLE (DEG)	>>>	COLLECTOR SIDE TUBE FINDER DIA. (FT)	>>>	COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE TUBE (INCH)	ARKER DIA. (FT)	COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	STORAGE SIDE FLUID VELOCITY (FT/SEC)	HEAT EXCHANGER LENGTH (FT)	HEAT EXCHANGER EFFECTIVENESS	NORMALIZED COLLECTOR FLOW (GPM/ARFAC)	STORAGE SIDE FLOW (GPM/ARFAC)	HEAT EXCHANGER EFFECTIVENESS	SOLAR ENERGY DELIVERED (BTU/YEAR)	TOTAL ENERGY DEMAND (BTU/YEAR)	ADJUSTED AVERAGE SOLAR LOAD FACTOR	HEX CHIEFFICIENT NPV OF SOLAR INVESTMENT	HEX CHIEFFICIENT (HTC/HR FT**2)	TOTAL INSTALLATION COST (\$)	COLLECTOR FLOW FACTOR (FPP)
517.5	>>>	1264.0	>>>	21.0	>>>	26.7	>>>	43.0	>>>	0.1473E 08	0.2637E 07	0.8280E 08	0.3105E 08	0.1329E 08	0.2637E 07	0.8280E 08	0.3105E 08	0.1329E 08	0.2637E 07	0.8280E 08	0.3105E 08	0.1329E 08	0.2637E 07
788.5	>>>	1083.0	>>>	26.7	>>>	32.4	>>>	53.6	>>>	0.1170E 08	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07	0.2332E 07
1204.8	>>>	1012.0	>>>	32.4	>>>	43.0	>>>	62.6	>>>	0.1093E 08	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07	0.2537E 07
1537.2	>>>	661.4	>>>	43.0	>>>	53.6	>>>	70.8	>>>	0.7143E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07
1832.7	>>>	359.7	>>>	53.6	>>>	62.6	>>>	70.8	>>>	0.5851E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07
2156.0	>>>	127.6	>>>	62.6	>>>	70.8	>>>	69.5	>>>	0.1373E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07
2329.0	>>>	17.3	>>>	70.8	>>>	57.8	>>>	46.9	>>>	0.1868E 06	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07
2006.0	>>>	34.5	>>>	57.8	>>>	46.9	>>>	35.6	>>>	0.3704E 06	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07
1502.0	>>>	241.8	>>>	46.9	>>>	35.6	>>>	25.3	>>>	0.6070E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07
1006.0	>>>	562.0	>>>	35.6	>>>	25.3	>>>		>>>	0.1151E 08	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07	0.2552E 07
591.0	>>>	573.0	>>>	25.3	>>>		>>>		>>>	0.1329E 08	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07	0.2637E 07
441.4	>>>	1230.8	>>>		>>>		>>>		>>>	0.8280E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08	0.3105E 08
	>>>	7666.9	>>>		>>>		>>>		>>>														

----- SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 3111
IMOC-1 LWK AUGUST 1979

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	

HEAT LOAD CHARACTERISTICS	
LOAD LCSS	Coefficient (BTU/HR F FT**2)
LOAD SURFACE	HEAT TRANSFER AREA (FT**2)
LOAD CONDUCTANCE	(BTU/DEG F DAY)
DOMESTIC HOT WATER (LFW)	DESIGN TEMP.
ESTIMATED DAILY DHW	USAGE (GAL/PER)
ESTIMATED CPW	USERS (PER)
ESTIMATED STORAGE	TO LOAD EFFECTIVENESS

COLLECTOR FLUID MEAN TEMPERATURE	
COLLECTOR FLUID DENSITY	(LB/FT**3)
COLLECTOR FLUID SPECIFIC HEAT	(BTU/LB*F)
COLLECTOR FLUID CONDUCTIVITY	(BTU/HR*FT*F)
STORAGE FLUID MEAN TEMPERATURE	.....
STORAGE FLUID DENSITY	(LB/FT**3)
STORAGE FLUID SPECIFIC HEAT	(BTU/LB*F)
STORAGE FLUID CONDUCTIVITY	(BTU/HR*FT*F)
COLLECTOR SIDE FOULING FACTOR	(HR F/BTU)
STORAGE SIDE FOULING FACTOR	(HR F/BTU)
HEX TUBE CONDUCTIVITY	(BTU/HR*FT*F)
ESTIMATED OPTIMUM STORAGE	(LB/AREAC)
ESTIMATED GROUND REFLECTANCE	.....
ESTIMATED PUMPING POWER	(KW/F AREAC)
ESTIMATED CORRECTION FOR TAIL ALPHA	PPED
ESTIMATED INSTALL/LABOR COST	(\$/AREAC)
ESTIMATED HEX COST	(\$/FT**2)
ESTIMATED STORAGE TANK COST	(\$/LB STORED)
MAINTENANCE (% INSTALL)	COST/YR)

* * * * * S O L A R - 1
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 * * * * * RESULTS OF ANALYSIS FOR SALEM OREGON
 * * * * * >>>> DATA MATCH TO INPUT ID NO. 3111
 * * * * * JMC0-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/DAY	EXTRA-TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2			
JAN	232.1	783.5	39.7	0.2350E 08	0.2637E 07	1034.2		1.602	0.009
FEB	588.0	642.5	42.3	0.1927E 08	0.2382E 07	1484.8		1.473	0.038
MAR	547.1	638.9	44.4	0.1917E 08	0.2637E 07	2169.4		1.250	0.070
APR	1370.4	493.6	48.6	0.1481E 08	0.2552E 07	2919.6		1.071	0.116
MAY	1737.8	316.2	54.9	0.9486E 07	0.2637E 07	3456.1		0.962	0.200
JUN	1841.6	154.7	60.6	0.4641E 07	0.2552E 07	3755.5		0.917	0.318
JUL	2142.4	40.2	66.2	0.1386E 07	0.2637E 07	3635.9		0.938	0.632
AUG	1774.7	50.1	65.4	0.1503E 07	0.2637E 07	3156.7		1.024	0.566
SEP	1328.3	140.6	61.0	0.4218E 07	0.2552E 07	2446.9		1.210	0.317
OCT	769.1	397.1	52.2	0.1191E 08	0.2637E 07	1700.2		1.431	0.095
NOV	410.4	605.6	44.8	0.1817E 08	0.2552E 07	1135.5		1.611	0.024
DEC	277.4	748.0	40.9	0.2244E 08	0.2637E 07	904.9		1.656	0.003
TOTAL		5017.0		0.1505E 09	0.3105E 08			AVERAGE	0.101

>>>WEIGHTED AVERAGE OTHER PARAMETERS

DESIGN VARIABLES / CONSTRAINTS	VALUES
COLLECTOR AREA (FT**2)	>>>
COLLECTOR TILT ANGLE (DEG)	>>>
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>
COLLECTOR SIDE TUBE OUTER DIA. (FT)	...
STORAGE SIDE TUBE (HEX) INNER DIA. (FT)	...
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	...
STORAGE SIDE FLUID VELOCITY (FT/SEC)	...
HEAT EXCHANGER LENGTH (FT)	...
HEX ANNUAL CAPACITY (BTU/HR)	...
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	...
COLLECTOR SIDE REYNOLDS NUMBER	...
STORAGE SIDE REYNOLDS NUMBER	...
CAPACITY RATE ((GPM/HR) * 2)	...
FLOW PARAMETER Z1 ((GPM/HR) * 2)	...
FLOW PARAMETER Z1 ((GPM/HR) * 2)	...

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM OREGON

>>>>DATA MATCH TO INPUT ID NC. 3112
 1400-1 LMK AUGUST 1975

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.1598E 08	0.2637E 07	1034.2	1.666	0.012
FEB	589.0	642.5	42.3	0.1311E 08	0.2382E 07	1484.8	1.476	0.052
MAR	947.1	638.9	44.4	0.1303E 08	0.2637E 07	2165.4	1.251	0.097
APR	1270.4	493.6	48.6	0.1007E 08	0.2552E 07	2919.6	1.070	0.156
MAY	1737.8	316.2	54.5	0.6450E 07	0.2637E 07	3496.1	0.960	0.260
JUN	1841.5	154.7	60.6	0.3156E 07	0.2552E 07	3755.5	0.915	0.387
JUL	2142.4	46.2	66.2	0.9425E 06	0.2637E 07	3635.9	0.936	0.684
AUG	1774.7	50.1	65.4	0.1022E 07	0.2637E 07	3156.7	1.033	0.618
SEP	1328.3	140.6	61.0	0.2368E 07	0.2552E 07	2446.9	1.211	0.383
OCT	769.4	397.1	52.2	0.8101E 07	0.2637E 07	1700.3	1.453	0.127
NOV	410.4	605.0	44.8	0.1235E 08	0.2552E 07	1135.5	1.615	0.033
DEC	277.4	748.0	40.9	0.1526E 08	0.2637E 07	904.9	1.660	0.005
TOTAL		5017.0		0.1023E 09	0.3105E 08			
>>>WEIGHTED AVERAGE C.134								
OTHER PARAMETERS								
COLLECTOR AREA (FT**2)								
TILT ANGLE (DEG)								
COLLECTOR TUBE INNER DIA. (FT)								
COLLECTOR TUBE OUTER DIA. (FT)								
COLLECTOR TUBE DIA. (FT)								
STORAGE TUBE(HEX) INNER DIA. (FT)								
COLLECTOR TUBE FLUID VELOCITY (FT/SEC)								
STORAGE TUBE FLUID VELOCITY (FT/SEC)								
HEAT EXCHANGER LENGTH (FT)								
HEAT EXCHANGER EFFECTIVENESS								
HEX ANNUAL DIAPYCN DIFFERENCE (FT)								
COLLECTOR TUBE DIA. DIFFERENCE(FT)								
COLLECTOR TUBE REYNOLDS NUMBER								
STORAGE TUBE REYNOLDS NUMBER								
CAPACITY RATIO (CMIN/CMAX)								
FLOW PARAMETER Z1(GCP/FRUL)								
FLOW PARAMETER Z1(GCP/FRUL)								
COLLECTOR SIDE CAPACITY (BTU/HR F)								
STORAGE SIDE CAPACITY (BTU/HR F)								
COLLECTOR SIDE CONVECTION COEFF								
STORAGE SIDE CONVECTION COEFFICIENT								
COLLECTOR SIDE FLOW RATE (GPM)								
STORAGE SIDE FLOW RATE (GPM)								
NORMALIZED COLLECTOR FLOW (GPM/AREAC)								
NORMALIZED STORAGE FLOW (GPM/AREAC)								
HEAT EXCHANGER DELIVERED (BTU/YEAR)								
SOLAR ENERGY DEMAND (BTU/YEAR)								
TOTAL ENERGY DEMAND (BTU/YEAR)								
ANNUAL AVERAGE SOLAR LOAD FRACTION								
OBJECTIVE: NPV OF SOLAR INVESTMENT								
HEX COEFFICIENT (BTU/HR F FT**2)								
TOTAL INSTALLATION COST (\$)								
COLLECTOR FLOW FACTOR(FPP)								

>>>>>DARA MARCH TO OUTPOST ID NO. 3213
I40D-1 LNK AUGUST 1979

SELECTED PARAMETERS

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	TIL
1	CIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELE	0.59	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR-F-FT**2) :	0.02
LOAD SURFACE HEAT TRANSFER AREA (FT**2) :	5000.00
LOAD CONDUCTANCE (BTU/DEG-F-DAY) :	10799.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP. :	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) :	20.00
ESTIMATED DHW USERS (PER) :	3.00
ESTIMATED SHOWERAGE TO LOAD EFFECTIVENESS :	1.00

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....**F)
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....**F)
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(HR*F/BTU)
STORAGE SIDE FOULING FACTOR(HR*F/BTU)
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM SURFACE(LB/AR*FAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KW/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PFD.....
ESTIMATED INSTALL/LABOR COST ($/AR*AC).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST ($/LP STOPED)
ESTIMATED MAINTENANCE ($ INSTALLED COST/YR).....

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176.00
160.81
1.0000
104.00
122.05
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
10.93
15.00
0.08
0.00

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM OREGON

>>>>DATA MARCH TO INPUT IN: 213
 0400-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSCLATION	HEATING DEGREES CAYS	AMBIENT TEMPERATURE DEG F	HEATING LOAD BTU/MONTH	DHW LOAD BTU/MONTH	EXTRA- TERRESTRIAL INSCLATION BTU/DAY FT**2	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	522.1	785.5	39.7	0.8462E 07	0.2637E 07	1034.2	1.626	0.028
FEB	588.0	642.5	42.3	0.6939E 07	0.2382E 07	1484.8	1.450	0.111
MAR	547.1	638.9	44.4	0.6900E 07	0.2637E 07	2169.4	1.255	0.156
APR	1370.4	495.6	48.6	0.5331E 07	0.2552E 07	2919.6	1.067	0.300
MAY	1737.8	316.2	54.9	0.3415E 07	0.2637E 07	3456.1	0.952	0.451
JUN	1841.6	154.7	60.6	0.1671E 07	0.2552E 07	3755.5	0.906	0.589
JUL	2142.4	46.2	66.2	0.4990E 06	0.2637E 07	3635.5	0.927	0.853
AUG	1774.7	50.1	65.4	0.5411E 06	0.2637E 07	3156.7	1.028	0.750
SEP	1328.3	140.6	61.0	0.1518E 07	0.2552E 07	2446.9	1.213	0.584
OCT	769.4	397.1	52.2	0.4289E 07	0.2637E 07	1700.3	1.445	0.243
NOV	410.4	605.6	44.8	0.6540E 07	0.2552E 07	1139.5	1.635	0.071
DEC	277.4	748.0	40.5	0.8078E 07	0.2637E 07	904.9	1.683	0.013
TOTAL		5017.0		0.5418E 08	0.3105E 08		AVERAGE	0.244

>>>WEIGHTED AVERAGE

DESIGN VARIABLES/CONSTRAINTS

DESIGN VARIABLES/CONSTRAINTS	OTHER PARAMETERS
COLLECTOR AREA (FT**2)	COLLECTOR SIDE CAPACITY (BTU/HR FT)
COLLECTOR TILT ANGLE (DEG)	STORAGE SIDE CAPACITY (BTU/HR FT)
COLLECTOR SIDE TUBE INNER DIA. (FT)	COLLECTOR SIDE CONVECTION COEFF
COLLECTOR SIDE TUBE OUTER DIA. (FT)	STORAGE SIDE CONVECTION COEFFICIENT
STORAGE SIDE TUBE (HELX) INNER DIA. (FT)	COLLECTOR SIDE FLOW RATE (GPM)
STORAGE SIDE TUBE FLUID VELOCITY (FT/SEC)	STORAGE SIDE FLOW RATE (GPM)
STORAGE SIDE FLUID VELOCITY (FT/SEC)	NORMALIZED COLLECTOR FLOW (GPM/AREAC)
HEAT EXCHANGER LENGTH (FT)	NORMALIZED STORAGE FLOW (GPM/AREAC)
HEAT EXCHANGER DIA. (FT)	HEAT EXCHANGER EFFECTIVENESS
HEX ANNULAR DIAMETER DIFFERENCE (FT)	SOLAR ENERGY DELIVERED (BTU/YEAR)
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	TOTAL ENERGY DEMAND (BTU/YEAR)
COLLECTOR SIDE REYNOLDS NUMBR	ANNUAL AVERAGE SOLAR LOAD FRACTION
STORAGE SIDE REYNOLDS NUMBR	PROJECTIVE NPV OF SOLAR INVESTMENT
CAPACITY RATIO (CAP/HEX)	HEX COEFFICIENT (BTU/HR FT**2)
FLOW PARAMETER Z1 (CCP/FRUL)	TOTAL INSTALLATION COST (\$)
FLOW PARAMETER Z1 (CCP/FRPUL)	COLLECTOR FLOW FACTOR (FPP)

S O L O A D - 1
SCALAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN
DESIGN DATA OPTIMIS/INPUTS SUMMARY

>>>>DATA WATCH F1 OUTPUT ID NO. 3222
IMD-1 LK AUGUST 1979

LOCATION	SALEM	OREGON	COLLECTOR AMERICAN SU4	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		3	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE DEGREES.....		44.92	SLOPE:		
MEAN TEMPERATURE.....		51.75	PARAMETER, FRUL....		20.00
UNSL(BTU/DAY FT**2)		1126.63	INTERCEPT:	SYSTEM LIFE(YEARS)..	C.0900
LOAD FACTOR, HDD.....		5017.00	PARAMETER, FRFA....	DISCOUNT RATE	O.1100
LEAN GROUND TEMP.....		59.00	BASE COST, \$/FT**2...	INFLATION RATE.....	

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY BASE		COST	HEATING VALUE	
	TYPE	EFFICIENCY		(\$/GAL)	(BTU/GAL)
1	OIL	0.70	0.50	142000.0	(BTU/GAL)
2	ELL	0.99	0.05	3413.0	(BTU/KWH)
3	GAS	0.70	0.40	100000.0	(BTU/TIM)

WHAT CHARACTERISTICS

LCAD	LOSS COEFFICIENT (BTU/HR FT*2)	0.17
LCAD	SURFACE HEAT TRANSFER AREA (FT*2)	500.00
LCAD	CONDUCTANCE (BTU/DEG F DAY)	20399.99
LCME	HEATING WATER DESIGN TEMP.	140.00
LCME	ESTIMATED DAILY DWG USEAGE (GAL/PER)	20.00
LCME	ESTIMATED DWG USEAGE (PER)	6.00
LCME	ESTIMATED STORAGE IN LCUE EFFECTIVE LINES	1.00

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT**F)
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT**F)
COLLECTOR SIDE FLOWING FACTOR(HR*F/RTU)
STORAGE SIDE FLOWING FACTOR(HR*F/RTU)
HEX TUBE CONDUCTIVITY(BTU/HR*FT**F).....
ESTIMATED OPTIMUM STORAGEE(LB/AREAC).....
ESTIMATED LIQUID REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PRED..
ESTIMATED INSTALL/LARCH COST ($/AR*AC)....
ESTIMATED HEX COST (LB/FT**2).....
ESTIMATED STORAGE TANK COST(LB/LB*STOR*F)
MAINTENANCE % INSTALLED COST/YR).....

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 S O L A R - I
 SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

 RESULTS OF ANALYSIS FOR SALEM OREGON
 * * * * *
 >>>>> DATA MATCH TC INPUT TO NC 3222
 1970-1 LNK AUGUST 1975

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/EAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	785.5	39.7	0.1598E	08	1034.2	1.640	0.022
FEB	538.0	642.5	42.3	0.1311E	08	1484.8	1.500	0.106
MAR	547.1	638.9	44.4	0.1303E	08	2169.4	1.258	0.193
APR	1370.4	493.6	48.6	0.1007E	07	2515.2	1.063	0.304
MAY	1757.8	316.2	54.9	0.6450E	07	3456.1	0.946	0.479
JUN	1841.0	154.7	60.6	0.3156E	07	3755.5	0.899	0.663
JUL	2142.4	46.2	66.2	0.9425E	06	3635.5	0.920	0.969
AUG	1774.7	50.1	65.4	0.1022E	07	3156.7	1.023	0.915
SEP	1328.3	140.6	61.0	0.2868E	07	2446.9	1.214	0.668
OCT	769.4	397.1	52.2	0.3101E	07	1700.3	1.454	0.253
NOV	410.4	605.6	44.8	0.1235E	08	1139.5	1.650	0.066
DEC	277.4	748.0	40.9	0.1526E	08	504.5	1.699	0.007
TOTAL		5017.0		0.1023E	09		AVERAGE	0.235

DESIGN VARIABLES/CONSTRAINTS

DESIGN VARIABLES/CONSTRAINTS	OTHER PARAMETERS
COLLECTOR AREA (FT**2)	>>>WEIGHTED AVERAGE
COLLECTOR TILT ANGLE (DEG)	COLLECTOR SIDE CAPACITY (BTU/HR F).....
COLLECTOR SIDE TUBE INNER DIA. (FT)	STORAGE SIDE CAPACITY (BTU/HR F).....
COLLECTOR SIDE TUBE CUTTER DIA. (FT)	COLLECTOR SIDE CONVECTION COEFF.
STORAGE SIDE TUBE (HX) INNER DIA. (FT)	STORAGE SIDE CONVECTION COEFFICIENT
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	COLLECTOR SIDE FLOW RATE (GPM)
STORAGE SIDE FLUID VELOCITY (FT/SEC)	STORAGE SIDE FLOW RATE (GPM)
HEAT EXCHANGER LENGTH (FT)	NORMALIZED COLLECTOR FLOW (GPM/AREAC)....
HEAT EXCHANGER DIAMETER (FT)	HEAT EXCHANGER EFFECTIVENESS.....
HEX ANNULAR DIAMETER DIFFERENCE (FT)	SOLAR ENERGY DELIVERED (BTU/YEAR).....
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	TOTAL ENERGY DEMAND (BTU/YEAR).....
COLLECTOR SIDE RYNOLDS NUMBER.....	ANNUAL AVERAGE SOLAR LOAD INVESTMENT
STORAGE SIDE RYNOLDS NUMBER.....	OBJECTIVE: NPV OF SOLAR INVESTMENT
CAPACITY RATIO (CMH/CM**X).....	HEX COEFFICIENT (BTU/HR F FT**2).....
FLOW PARAMETER Z2 (G/CF/FRUL).....	TOTAL INSTALLATION COST (\$)
FLOW PARAMETER Z1 (G/CF/FRUL).....	COLLECTOR FLOW FACTOR (FPP).....

DESIGN DATA OPTIMIS/IMPLIS SUMMARY

>>>>DATA WATCH TO OUTPUT ID NC. 3223
IMCD-1 LNK AUGUST 1979

[illegible]

SELECTED PARAMETERS

COLLECTOR	FLUID MEAN TEMPERATURE	176.00
COLLECTOR	FLUID DENSITY(LB/FT**3)	60.81
COLLECTOR	FLUID SPECIFIC HEAT(BTU/LB*F)	1.0000
COLLECTOR	FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE	FLUID MEAN TEMPERATURE	104.00
STORAGE	FLUID DENSITY(LB/FT**3)	62.00
STORAGE	FLUID SPECIFIC HEAT(BTU/LB*F)	1.0000
STORAGE	FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3640
COLLECTOR	SIDE FOULING FACTOR(HR F/FTU)	0.0010
STORAGE	SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE	CONDUCTIVITY(BTU/HR*FT*F)	220.00
ESTIMATED	OPTIMUM STORAGE(LB/A/EAC)	15.30
ESTIMATED	GROUND REFLECTANCE	0.20
ESTIMATED	PUMPING POWER(KWH/A/EAC)	1.0000
ESTIMATED	CORRECTION FOR TAU ALPHA PED.	0.93
ESTIMATED	INSTALL/LABOR COST (\$/A/EAC)	10.00
ESTIMATED	HEX COST (\$/FT**2)	5.00
ESTIMATED	STORAGE TANK COST(\$/LB STORED)	0.08
ESTIMATED	MAINTENANCE (% OF TANK COST/YR)	0.0010

Figure 1. Fluid conductivity (BTU/HE (T/F)).

ESTIMATED OPTIMUM STORAGE (LB/AFEAC)	15.30
ESTIMATED GROUND REFLECTANCE	0.20
ESTIMATED PUMPING POWER (KW/AFEAC)	1.0000
ESTIMATED CORRECTION FOR TAIL ALPHA FEED	0.93
ESTIMATED INSTALL/LABOR COST (1/AFEAC)	15.00
ESTIMATED HEX COST (\$/FT*2)	5.00
ESTIMATED STORAGE TANK COST (\$/LB STORED)	0.08
ESTIMATED FENCE (% INSTALLED COST/YR)	0.0010

>>>>DATA MATCH TO INPUT ID NO. 3223
MOD-1 LWK AUGUST 1979

>>>>DATA MATCH TO INPUT ID NO. 3223
MOD-1 LWK AUGUST 1979

>>>WEIGHTED AVERAGE OTHER PARAMETERS

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COLLECTOR SIDE CAPACITY (BTU/HF F) .....
STORAGE SIDE CAPACITY (RTU/HR F) .....
COLLECTOR SIDE CONVECTION COEFF. ....
STORAGE SIDE CONVECTION COEFF. ....
COLLECTOR SIDE FLOW RATE (GPM) .....
STORAGE SIDE FLOW RATE (GPM) .....
NORMALIZED COLLECTOR FLOW (GPM/AREAC) .....
NORMALIZED STORAGE FLOW (GPM/APEAC) .....
HEAT EXCHANGE EFFECTIVENESS .....
TOTAL ENERGY DEMAND (BTU/YEAR) .....
ANNUAL AVERAGE SOLAR LOAD FRACTION .....
OBJECTIVE: NPV OF SOLAR INVESTMENT >>>
HEAT COEFFICIENT (BTU/HF F T**2) .....
TOTAL INSTALLATION COST ($) .....
COLLECTOR FLOW FACTOR(FPP) .....

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SL 140-1

SQUARE ENERGY OPTIMIZATION ANALYSIS FOR DESIGN

DI-STAY DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH ID NC. 3232
IMCD-1 LJK AUGUST 1979

LOCATION	SALEM	OREGON	COLLECTOR	FEDERAL PRISON I. D	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		3	COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....		44.92	SLOPE:			
MEAN TEMPERATURE.....		51.75	PARAMETER, FRUL....	0.8830	SYSTEM LIFE (YEARS)...	20.00
INSOL (BLU/DAY FT*2)		1126.63	INTERCEPT:		DISCOUNT RATE.....	0.0900
LOGAC FACTOR, HD0.....		5017.00	PARAMETER, FRIA....	0.6270	INFLATION RATE.....	0.1100
LOGAC FACTOR, H10.....		55.00	BASE COST, \$/FT*2...	9.40		

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASIS	EFFICIENCY	COST	HEATING VALUE	J/L
1	OIL		0.79	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELF		0.79	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	BAS		0.70	0.40 (\$/TJ)	100000.0 (KJ/TJ)	

HEAT TREAT CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR L FTR*2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FTR*2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	2039.09
DOMESTIC HOT WATER (DEW) FLOW TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW LOSS (PER) ..	6.00
ESTIMATED SAVINGS TO LOAD EFFECT-TIMES ..	1.00

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COLLECTOR FUID MEAN TEMPERATURE.....
COLLECTOR FUID COMSTY(LR/FT**3).....
COLLECTOR FUID SPECIFIC HEAT(BTU/LR*F).....
COLLECTOR FUID CONDUCTIVITY(BTU/LR*F*F).....
STORAGE FUID MEAN TEMPERATURE.....
STORAGE FUID DENSITY(LB/FT**3).....
STORAGE FUID SPECIFIC HEAT(BTU/LR*F).....
STORAGE FUID CONDUCTIVITY(BTU/LR*F*F).....
COLLECTOR SIDE FUELING FACTOR(HR F/RU).....
STORAGE SIDE FUELING FACTOR(HR F/RU).....
TUBE CONDUCTIVITY(BTU/HP F F).....
ESTIMATED OPTIMUM STORAGE(LR/AREAC).....
ESTIMATED GRAVITY REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FACTOR ALPHA FREQ.....
ESTIMATED INSTALL/LABOR COST ($/A-ENG).....
ESTIMATED FIX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LB ST(RED)
ESTIMATED INFLUENCE OF INSTALL COST(YR).....

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176.00
60.81
1.0000
0.3870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.36
0.20
1.0000
0.93
10.00
5.00
0.08
0.0010

SULLAD-1

SCALAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM CRT-GOBI

>>>>DATA MATCH TC INPRF ID NC. 3232
MDD-1 LWK AUGUST 1979

16. IMPROVING THE QUALITY OF THE ENVIRONMENT
1979-1980

MONTH	HORIZONTAL INSULATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE		HEATING LOAD		DHW LOAD		EXTRA-TERRRESTRIAL INSULATION		COLLECTOR TILT FACTOR		SOLAR ENERGY FRACTION	
	BTU/DAY	FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2	BTU/DAY	FT**2	BTU/DAY	FT**2	BTU/DAY	FT**2
JAN	332.1		783.5	39.7	0.1598E	08	0.2637E	07	1034.2		1.640		0.032			
FEB	588.0		642.5	42.3	0.1311E	08	0.2382E	07	1484.8		1.500		0.110			
MAR	947.1		638.9	44.4	0.1303E	08	0.2637E	07	2169.4		1.258		0.191			
APR	1370.4		493.6	48.6	0.1007E	08	0.2552E	07	2515.6		1.063		0.255			
MAY	1737.8		316.2	54.9	0.6450E	07	0.2637E	07	3490.1		0.946		0.465			
JUN	1841.6		154.7	50.6	0.3156E	07	0.2552E	07	3755.5		0.859		0.650			
JUL	2142.4		46.2	66.2	0.9425E	06	0.2637E	07	3635.9		0.920		0.576			
AUG	1774.7		50.1	65.4	0.1022E	07	0.2637E	07	3156.7		1.023		0.920			
SEP	1328.3		140.6	61.0	0.2368E	07	0.2552E	07	2446.5		1.214		0.657			
OCT	769.4		397.1	52.2	0.6101E	07	0.2637E	07	1700.3		1.453		0.251			
NOV	410.4		605.6	44.8	0.1235E	08	0.2552E	07	1155.5		1.649		0.074			
DEC	277.4		148.0	40.9	0.1526E	08	0.2637E	07	904.9		1.659		0.018			
TOTAL			5017.0		0.1023E	09	0.3105E	08	>>>WEIGHTED AVERAGE				0.236			

DEUTIG VASJABLS/POSTRAITS

COLLECTOR AREA (FT**2)	>>>	213.36	COLLECTOR SIDE CAPACITY (BTU/HF F)	0.183E 04
COLLECTOR TAIL ANGLE (DEG)	>>>	37.51	STORAGE SIDE CAPACITY (BTU/HF F)	0.430E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	0.0597	COLLECTOR SIDE CONVECTION COEFF.	1037.5957
COLLECTOR SIDE TUBE OUTER DIA. (FT)		0.0697	STORAGE SIDE CONVECTION COEFFICIENT	3721.4675
C/STORAGE SIDE TUBE(LX) INNER DIA. (FT) ..		0.1321	COLLECTOR SIDE FLOW RATE (GPM)	3.7508
C/STORAGE SIDE TUBE(LX) OUTER DIA. (FT) ..		2.9737	STORAGE SIDE FLOW RATE (GPM)	90.4347
C/STORAGE SIDE FLUID VELOCITY (FT/SEC) ..		19.4650	NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0172
C/HEAT EXCHANGER LENGTH (FT)		36.64	NORMALIZED STORAGE FLOW (GPM/AREA)	0.3558
/////////////////COLLECTOR TUBES PER ROW			HEAT EXCHANGER EFFECTIVENESS	0.9347
C/ANNULAR DIAMETER DIFFERENCE (FT) ..		0.0626	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.415E 08
C/COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT).		0.0095	TOTAL ENERGY DEMAND (BTU/YEAR)	0.133E 09
C/COLLECTOR SIDE RYIELDS PER HOUR		0.454E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2321
C/STORAGE SIDE RYIELDS PER HOUR		0.172E 06	C/OBJECTIVE: NPV OF SOLAR INVESTMENT	>>>
C/CAPACITY RATIO (CAPT/CM*X)		0.0425	HEX EFFICIENCY FACTOR (FT**2)	0.198E 04
C/FLOW PARAMETER Z1(CM/HOUR)		9.4383	TOTAL INSTALLATION COST (\$)	315.41
C/FLOW PARAMETER Z1(CM/PERIOD)		3.98	COLLECTOR FLOW FACTOR(FPP)	584.81
				0.9467

>>>>>DATA MATCH TO OUTPUT ID NO. 3253
INAD-1 LWK AUGUST 1979

112

5 JUL 80 - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN

RESULTS OF ANALYSIS FOR SALEM REGION

>>>>DATA MATCH TO INPUT ID NO. 3233
MOD-1 LWR AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	DEW LOAD	EXTRA-TERRRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.8762E 07	0.2637E 07	0.2637E 07	1024.2	1.435	0.041
FEB	586.0	642.5	42.3	0.6939E 07	0.2382E 07	0.2382E 07	1484.8	1.496	0.136
MAR	947.1	638.9	44.4	0.6900E 07	0.2382E 07	0.2382E 07	2165.4	1.257	0.233
APR	1270.4	453.6	43.6	0.5331E 07	0.2252E 07	0.2252E 07	2919.6	1.065	0.351
MAY	1737.9	316.2	54.9	0.3415E 07	0.2637E 07	0.2637E 07	3456.1	0.948	0.518
JUN	1841.6	154.7	60.6	0.1671E 07	0.2552E 07	0.2552E 07	3755.5	0.901	0.665
JUL	2142.4	46.2	66.2	0.4990E 06	0.2637E 07	0.2637E 07	3635.9	0.923	0.931
AUG	1774.7	51.1	65.4	0.5411E 06	0.2637E 07	0.2637E 07	3156.7	1.025	0.870
SEP	1228.3	140.6	61.0	0.1518E 07	0.2552E 07	0.2552E 07	2446.9	1.213	0.663
OCT	759.4	397.1	52.2	0.4269E 07	0.2637E 07	0.2637E 07	1700.3	1.451	0.290
NOV	419.6	605.6	47.8	0.6290E 07	0.2552E 07	0.2552E 07	1135.5	1.644	0.051
DEC	277.4	748.0	40.5	0.8078E 07	0.2637E 07	0.2637E 07	904.3	1.693	0.023
TOTAL		5017.0		0.5418E 08	0.3105E 08	0.3105E 08			0.263

>>>WEIGHTED AVERAGE

OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR FT)	0.140E 04
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR FT)	0.340E 04
COLLECTOR INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFFICIENT	851.2470
COLLECTOR OUTER DIA. (FT)		STORAGE SIDE CONVECTION COEFFICIENT	554.9177
STORAGE TUBE HPC(HX) TUBE DIA. (FT)		COLLECTOR SIDE FLOW RATE (GPM)	2.8754
STORAGE TUBE FLUID VELOCITY (FT/SEC)		STORAGE SIDE FLOW RATE (GPM)	66.2752
STORAGE TUBE FLUID VELOCITY (FT/SEC)		NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0173
HEAT EXCHANGER LENGTH (FT)		HEAT EXCHANGER STORAGE FLOW (GPM/AREA)	0.4053
HEAT EXCHANGER DIA. (FT)		HEAT EXCHANGER EFFECTIVENESS	0.9302
HEX ANNULAR DIA. (FT)		SOLAR ENERGY DELIVERED (BTU/YEAR)	0.841E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)		ANNUAL AVERAGE SOLAR LOAD FRACTION	0.8521 08
COLLECTOR SIDE TUBES TYPED		OBJECTIVE: TPA OF SOLAR INVESTMENT	0.193E 04
STORAGE TUBE TYPED		HEX COEFFICIENT (BTU/HR FT**2)	295.52
CAPACITY RATE (GPM/HR)		TOTAL INSTALLATION COST (\$)	352.55
FLOW PARAMETER Z1(COP/FLOW)		COLLECTOR FLOW FACTOR(FPP)	0.5466

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MARCH TO OUTPUT ID NO. 4111
INJD-1 LWK AUGUST 1979

LOCATION	PORTLAND	MAINE	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		4	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREE S....		43.65	SLOPE:		
MEAN TEMPERATURE....		45.38	PARAMETER, FRUL....		
INSOL (BTU/DAY FT**2)		1050.57	INTERCEPT:		
LOAD FACTOR, FDC....		7410.39	PARAMETER, FR TA....		
MEAN GROUND TEMP....		55.00	BASE COST, \$/FT**2...		
				ECONOMIC ESTIMATES	
				SYSTEM LIFE(YEARS)...	20.00
				DISCOUNT RATE.....	0.1150
				INFLATION RATE.....	0.1050

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	CIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELF	0.99	0.65 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	
HEAT LOAD CHARACTERISTICS					
LOAD LOSS COEFFICIENT (BTU/HR 1 FT**2) .. 0.25					
LOAD SURFACE HEAT TRANSFER AREA (FT**2) .. 5000.00					
LOAD CONDUCTANCE (BTU/DEC F DAY) .. 30000.00					
DOMESTIC HOT WATER (DHW) DESIGN TEMP. .. 140.00					
ESTIMATED DAILY DHW USAGE (GAL/PER) .. 20.00					
ESTIMATED DHW USERS (PER) .. 2.00					
ESTIMATED STORAGE THRU LOAD EFFECTIVENESS .. 1.00					

* * * * * S O L A R - 1
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 * * * * * --- RESULTS OF ANALYSIS FOR PORTLAND MAINE
 * * * * *
 * * * * * >>>> DATA MATCH TC INPUT ID NO. 4111
 * * * * * UM00-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DIY LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/CAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.3985E 08	0.2637E 07	1100.1	1.754	0.015
FEB	681.6	1152.7	24.2	0.3458E 08	0.2382E 07	1548.6	1.505	0.028
MAR	509.6	1013.4	32.3	0.3040E 08	0.2637E 07	2222.9	1.239	0.046
APR	1304.0	664.7	42.8	0.1994E 08	0.2552E 07	2553.7	1.050	0.081
MAY	1567.0	379.9	52.9	0.1140E 08	0.2637E 07	3509.2	0.941	0.148
JUN	1712.0	118.5	62.7	0.3555E 07	0.2552E 07	3757.2	0.898	0.330
JUL	1659.0	22.1	68.0	0.6630E 06	0.2637E 07	3642.1	0.918	0.554
AUG	1461.0	42.0	66.6	0.1260E 07	0.2637E 07	3182.9	1.004	0.468
SEP	1153.0	202.8	59.0	0.6084E 07	0.2552E 07	2494.3	1.170	0.205
OCT	822.3	502.1	48.8	0.1506E 08	0.2637E 07	1761.6	1.432	0.086
NOV	459.2	785.4	38.8	0.2356E 08	0.2552E 07	1205.3	1.632	0.024
DEC	302.8	1199.0	26.3	0.3597E 08	0.2637E 07	570.6	1.755	0.010
TOTAL		7410.4	0.2223E 09	0.3105E 08			AVERAGE	0.068

>>>WEIGHTED AVERAGE
OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.990E 03
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR F)	0.735E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFF. (BTU/HR F)	1832.0872
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFFICIENT	4701.6367
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)	>>>	COLLECTOR SIDE FLOW RATE (GPM)	2.0296
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>	STORAGE SIDE FLOW RATE (GPM)	147.5214
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0203
HEAT EXCHANGER LENGTH (FT)	>>>	NORMALIZED STORAGE FLOW (GPM/AREAC)	1.4752
HEAT EXCHANGER LENGTH (FT)	>>>	HEAT EXCHANGE EFFECTIVENESS	0.9428
HEX ANNULAR DIAMETER DIFFERENCE (FT)	>>>	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.171E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	>>>	TOTAL ENERGY DEMAND (BTU/YEAR)	0.253E 09
COLLECTOR SIDE REYNOLDS NUMBER	>>>	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.0675
STORAGE SIDE REYNOLDS NUMBER	>>>	OBJECTIVE: NPV OF SOLAR INVESTMENT	>>>-
CAPACITY RATIO (GPM/GMAX)	>>>	HEX COEFFICIENT (BTU/HR F FT**2)	366.27
FLOW PARAMETER 22 (GCP/FRUL)	>>>	TOTAL INSTALLATION COST (\$)	2598.57
FLOW PARAMETER 21 (GCP/FRUL)	>>>	COLLECTOR FLOW FACTOR(FFP)	0.9466

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>>>>DATA MATCH TO CUPUT ID NC. *112
IMOD-1 LWK AUGUST 1979

LOCATION	PORTLAND	MAINE	COLLECTOR SOLARMETICS	STUDY APPROACH	ANALYSIS
CLIMATE INDEX.....		4	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....		43.05	SLOPE:		
MEAN TEMPERATURE.....		45.38	PARAMETER, FRUL....		
INSOL (BTU/DAY FT#2)		1050.57	INTERCEPT:		
LOAD FACTOR, HDU.....		7410.39	PARAMETER, FRIA....		
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT#2...		
				ECONOMIC ESTIMATES	
				SYSTEM LIFE (YEARS)...	20.00
				DISCOUNT RATE.....	0.1150
				INFLATION RATE.....	0.1050

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	EAS L EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.17
LOAD SURFACIAL TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	20399.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP. ..	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	20.00
ESTIMATED DHW USERS (PER) ..	9.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS:	1.00

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY (LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT (BTU/LP*F).....
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY (LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT (BTU/LR*F).....
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR (HR F/RTU).....
STORAGE SIDE FOULING FACTOR (HR F/FTU).....
HEX TUBE CONDUCTIVITY (BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE (LB/AREAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER (KWH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PRE.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST ($/FT*2).....
ESTIMATED STORAGE TANK COST ($/LP STORED).....
ESTIMATED MAINTENANCE ($ INSTALLED COST/YR).....

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SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>> DATA MATCH TO OUTPUT ID NO. 4113
IMOD-1 LWK AUGUST 1979

LOCATION	PORTLAND	MAINE	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		4	COLLECTOR TEST RESULTS, SLOPE:	ECONOMIC ESTIMATES	
LATITUDE, DEGREES....		43.65	PARAMETER, FRUL....		
MEAN TEMPERATURE....		45.38	INTERCEPT:	SYSTEM LIFE(YEARS)...	20.00
INSOL (BTU/DAY FT*2)		1050.57	PARAMETER, FRIA....	DISCOUNT RATE	0.1150
LCAID FACTOR, FDC....		7410.39	BASE COST, \$/FT*2...	INFLATION RATE.....	0.1050
MEAN GROUND TEMP....		55.00			

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	UNIT
1	OIL	0.70	0.90 (\$/GAL)	142000.0	(BTU/GAL)
2	ELE	0.99	0.05 (\$/KWH)	3413.0	(BTU/KWH)
3	GAS	0.70	0.40 (\$/THERM)	100000.0	(BTU/THERM)

HEAT LOAD CHARACTERISTICS

LOAD	LCSS	COEFFICIENT	(BTU/HR.F	FT**2)}..	0.00
LOAD SURFACE HEAT	TCOA/SEC	AREA	(FT**2)}..	5000.00	
LOAD CONDUCTANCE	(BTU/DEG	F/INCH)		10799.99	
TIME ESTIMATED	WATER (DHW)	DESIGN TEMP.		140.00	
ESTIMATED DAILY	DHW USAGE	(GAL/PER)		20.00	
ESTIMATED DHW USES	(PERK)			0.00	
ESTIMATED STORAGE	TC LOAD	EFFECTIVENESS		1.00	

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COLLECTOR FLOW MEAN TEMPERATURE.....
COLLECTOR FLOW DENSITY(LB/FT**3).....
COLLECTOR FLOW SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLOW CONDUCTIVITY(BTU/HR FT F).....
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY(LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLOW CONDUCTIVITY(HU/HR FT F).....
COLLECTOR SIDE FLOWING FACTOR(HR F/BTU).....
HEX TUBE CONDUCTIVITY(BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE(LB/AREAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PRED.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LB STORED).....
ESTIMATED MAINTENANCE IF INSTALLED CIST/YR).....

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176.00
60.31
11.000
0.3870
104.00
62.09
1.000
0.3640
0.0010
0.0010
220.00
15.30
0.29
1.0000
0.53
10.00
5.00
0.08
0.01

S O L O A U - 1
 SOLAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN

 RESULTS OF ANALYSIS FOR PORTLAND MAINE
 >>>>>DATA MATCH TO INPUT ID NO. 4113
 JANU-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.1434E 08	0.2637E 07	1100.1	1.769	0.035
FEB	681.0	1152.7	24.2	0.1245E 08	0.2382E 07	1548.6	1.518	0.069
MAR	569.6	1013.4	32.3	0.1094E 08	0.2637E 07	2222.9	1.241	0.109
APR	1304.0	664.7	42.8	0.7179E 07	0.2552E 07	2953.7	1.046	0.178
MAY	1567.0	379.9	52.9	0.4103E 07	0.2637E 07	3505.2	0.935	0.287
JUN	1712.0	118.5	62.7	0.1280E 07	0.2552E 07	3757.2	0.891	0.478
JUL	1659.0	22.1	68.0	0.2387E 06	0.2637E 07	3643.1	0.911	0.606
AUG	1481.0	42.0	66.6	0.4536E 06	0.2637E 07	3182.3	1.000	0.554
SEP	1158.0	202.8	59.0	0.2190E 07	0.2552E 07	2494.3	1.170	0.348
OCT	822.3	502.1	48.8	0.5423E 07	0.2637E 07	1761.6	1.435	0.182
NOV	459.2	785.4	38.8	0.8462E 07	0.2552E 07	1205.3	1.645	0.057
DEC	302.8	1199.0	26.3	0.1295E 08	0.2637E 07	570.6	1.811	0.026
TOTAL		7410.4		0.8003E 08	0.3105E 08			0.146

DESIGN VARIABLES/CONSTRAINTS

>>>WEIGHTED AVERAGE
 OTHER PARAMETERS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HP F)	0.989E 03
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HP F)	0.571E 05
COLLECTOR TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFFICIENT	1292.2117
COLLECTOR SIDE TUBE CUTTER DIA. (FT)		STORAGE SIDE CONVECTION COEFFICIENT	4129.7383
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)		COLLECTOR SIDE FLOW RATE (GPM)	2.0281
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)		STORAGE SIDE FLOW RATE (GPM)	114.7034
STORAGE SIDE FLUID VELOCITY (FT/SEC)		NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0203
HEAT EXCHANGER LENGTH (FT)		HEAT EXCHANGER STORAGE EFFECTIVENESS	1.1470
HEAT EXCHANGER/CONSTRAINTS/	//////////	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.9313
HEX ANNULAR DIAMETER DIFFERENCE (FT)		TOTAL ENERGY DEMAND (BTU/YEAR)	0.163E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)		ANNUAL AVERAGE SOLAR LOAD FRACTION	0.111E 09
COLLECTOR SIDE REYNOLDS NUMBER		OBJECTIVE: NPV OF SOLAR INVESTMENT	0.1405
STORAGE SIDE REYNOLDS NUMBER		HEX COEFFICIENT (BTU/HP F FT**2)	-0.316E 03
CAPACITY RATIO (CMIN/CMAX)		TOTAL INSTALLATION COST (\$)	334.55
FLOW PARAMETER Z1(CCP/FRUL)		COLLECTOR FLOW FACTOR(FPP)	2999.80
FLOW PARAMETER Z1(CCP/FRUL)			0.9460

S O L I D - I
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIMIZATIONS SUMMARY

>>>> DATA WATCH TO OUTPUT ID NO. 4222
IMC0-1 LWR AUGUST 1979

SULLIVAN - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA TYPES/INPUTS SUMMARY

>>>>> DATA MATCH TO OUTPUT ID NO. 4222
IMCD-1 LWK AUGUST 1979

LCCATION	PORTLAND	MATTE	COLLECTOR	AMERICAN SUN	STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES						
LCCATION INDEX.....	4		SLOPE:			
LATITUDE, DEGREES.....	43.65		PARAMETER, FRUL....	1.0350		20.00
MEAN TEMPERATURE.....	45.38		INTERCEPT:			0.0900
INSL (BTU/DAY FT#2)	1050.57		PARAMETER, FRTA....	0.6380		0.1100
LOAD FACTOR, HDD.....	7410.35		BASE COST, \$/FT#2...	6.55		
MEAN GROUND TEMP.....	55.00					

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE
1	CH	0.70	0.30 (\$/GAL)	14200.0 (BTU/GAL)
2	ELE	0.59	0.25 (\$/KWH)	3413.0 (BTU/KWH)
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HK F F**2) :	0.17
LOAD SURFACE HEAT TRANSFER AREA (F**2) :	5000.00
LOAD CONDUCTANCE (BTU/DEC F DAY) :	20399.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP. :	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) :	20.00
ESTIMATED DHW USERS (PLR) :	2.00
ESTIMATED STORAGE TO LOAD EFFECTIVE JES :	1.00

SELECTED PARAMETERS

COLLECTOR FLOW MEAN TEMPERATURE.....	176.00
COLLECTOR FLOW DENSITY(LB/FT**2).....	60.81
COLLECTOR FLOW SPECIFIC HEAT(BTU/LB*F).....	1.0000
COLLECTOR FLOW CONDUCTIVITY(BTU/HR*FT*F).....	0.3870
STORAGE FLOW MEAN TEMPERATURE.....	104.00
STORAGE FLOW DENSITY(LB/FT**3).....	62.09
STORAGE FLOW SPECIFIC HEAT(BTU/LB*F).....	1.0000
STORAGE FLOW CONDUCTIVITY(BTU/HR*FT*F).....	0.3640
COLLECTOR SIDE FLOWING FACTOR(HR*F/RTU).....	0.0010
STORAGE SIDE FLOWING FACTOR(HR*F/RTU).....	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....	220.00
ESTIMATED OPTIMUM REFLECTANCE.....	15.30
ESTIMATED GROUND REFLECTANCE.....	0.20
ESTIMATED PUMPING POWER(KWH/AREAC).....	1.0000
ESTIMATED CORRECTION FACTOR ALPHA PRFD.....	0.93
ESTIMATED INSTALL/LABOR COST (\$/ARLAC).....	10.00
ESTIMATED HEX COST (4/F**2).....	5.00
ESTIMATED STORAGE TANK COST(\$/LB STOPED).....	0.08
MAINTENANCE (% INSTALLED COST/YR).....	0.0010

SOLAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH TC INPUT ID NO. +222
MOD-I LWR AUGUST 1979

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LOCATION	PORTLAND	MAINE	COLLECTOR	AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		4	COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATES	
LATITUDE, DEGREE.....		43.65	SLOPE:			
MEAN TEMPERATURE.....		45.38	PARAMETER, FRUL....	1.0390		20.00
HOURS (PTU/DAY FT**2)		1056.57	INTERCEPT:		SYSTEM LIFE (YEARS)...	C.0900
HEAT FACTOR, HDU.....		7410.39	PARAMETER, FRTA....	0.6380	DISCOUNT RATE	C.1100
MEAN GROUND TEMP.....		55.00	BASL COST, \$/FT**2...	6.55	INFLATION RATE.....	

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	EFFICIENCY	COST	HEATING VALUE	BTU/GAL
1	OIL	0.70	0.90 (\$/GAL)	142000	0.0 (BTU/GAL)
2	FUEL	0.99	0.35 (\$/KWH)	3415	0.0 (BTU/KWH)
3	GAS	0.70	0.40 (\$/THERM)	100000	0.0 (BTU/THERM)

HEAT LOAD CHARACTERISTICS

Variable	Value
LOAD LOSS COEFFICIENT (BTU/IN ² ·H ² ·°F)	0.09
LOAD SURFACE HEAT TRANSFER AREA (FT ²)	5000.00
LOAD CONDUCTANCE (BTU/DEGREE DAY)	10799.99
DOMESTIC HOT WATER (GPM) DESIGN TEMP.	140.00
ESTIMATED DAILY DRW USAGE (GAL/PER)	20.00
ESTIMATED DAILY DRW (PER)	6.00
ESTIMATED STORAGE LOAD EFFECTIVENESS	1.00

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LR*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LR*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(F/F/PTU).....
STORAGE SIDE FOULING FACTOR(F/F/PTU).....
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE(LP/AREAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/4E*AC).....
ESTIMATED CURFECTION FOR TAU ALPHA CFED.....
ESTIMATED INSTALL/LABOR COST (1/A*EAC).....
ESTIMATED HEX COST (3/FT*2).....
ESTIMATED STORAGE TANK COST(4/LP*STCFD).....
MAINTENANCE & INSTALLED COST(YR).....

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SOLAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH TO INPUT ID NC. 4223
UMCD-1 L/K AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AIRFILT TEMPERATURE	HEATING LOAD	QHW LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.134E 08	0.2637E C7	1100.1	1.754	0.063
FEB	681.6	1152.7	24.2	0.1245E 08	0.2382E 07	1548.6	1.532	0.114
MAR	969.0	1013.4	32.3	0.1094E 08	0.2637E C7	2222.9	1.243	0.173
APR	1304.0	664.7	42.8	0.7179E 07	0.2552E C7	2953.7	1.040	0.286
MAY	1507.0	375.5	52.9	0.4103E 07	0.2637E C7	3509.2	0.925	0.444
JUN	1712.0	118.5	62.7	0.1280E 07	0.2552E C7	3757.2	0.879	0.685
JUL	1659.0	22.1	68.0	0.2587E 06	0.2637E 07	3643.1	0.900	0.812
AUG	1461.0	42.0	66.6	0.4536E 06	0.2637E C7	3182.9	0.992	0.764
SEP	1158.0	202.8	59.0	0.2190E 07	0.2552E 07	2454.3	1.165	0.528
OCT	822.3	502.1	48.8	0.5423E 07	0.2637E 07	1761.6	1.449	0.295
NOV	459.2	785.4	38.8	0.8482E 07	0.2552E C7	1205.3	1.665	0.093
DEC	362.8	1199.0	26.3	0.1295E 08	0.2637E 07	970.6	1.839	0.041
TOTAL		7410.4		0.8003E 08	0.3105E C8	>>>WEIGHTED AVERAGE		0.223

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FROM AN ENERGY OPTIMIZATION ANALYSIS TO DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>> DATA MATCH	TU OUTPUT ID NO.	4232
	IMCD-1 LNK AUGUST	1979

ANALYSIS

SELECTED PARAMETERS

COLLECTOR	FLUID MEAN TEMPERATURE	176.00
COLLECTOR	FLUID DENSITY(LB/FT**3)	60.81
COLLECTOR	FLUID SPECIFIC HEAT(BTU/LP*F)	1.0000
COLLECTOR	FLUID CONDUCTIVITY(BTU/HR*F*F)	0.3870
STORAGE	FLUID MEAN TEMPERATURE	104.00
STORAGE	FLUID DENSITY(LB/FT**3)	62.09
STORAGE	FLUID SPECIFIC HEAT(BTU/LP*F)	1.0000
STORAGE	FLUID CONDUCTIVITY(BTU/HR*F*F)	0.3640
COLLECTOR	SLIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE	SLIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TURE	CONDUCTIVITY(BTU/HR*F*F)	220.00
ESTIMATED	OPTIMUM STORAGE(LB/AFTAC)	15.30
ESTIMATED	GROUND REFLECTANCE	0.20
ESTIMATED	PUMPING POWER(KWH/AFTAC)	1.0000
ESTIMATED	CORRECTION FOR TAU ALPHA PFED	0.93
ESTIMATED	INSTALL/LABOR COST (\$/AFTAC)	10.00
ESTIMATED	HEX COST (\$/FT**2)	5.00
ESTIMATED	STORAGE TANK COST (\$/LP STORED)	0.08
MAINTENANCE	CY INSTALLED COST/YR	0.0010

STORAGE FLUID CONDUCTIVITY (BTU/HR FT F)
COLLECTOR SIDE FOULING FACTOR (HR F/FTU)
STORAGE FLUID FOULING FACTOR (HR F/FTU)
HEX TUBE CONDUCTIVITY (BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE (LB/AREAC)
ESTIMATED PUMPING POWER (KWH/AEAC).....
ESTIMATED CORRECTION FOR TAI ALPHA PFED:
ESTIMATED INSTALL/LABOR COST (\$/AREAC).....
ESTIMATED HEX COST (\$/FT*2)
ESTIMATED STORAGE TANK COST (\$/LP STORED)
MAINTENANCE & INSTALLED COST/YR).....

ESTIMATED OPTIMUM STORAGE (LB/AFTAC)	15.36
ESTIMATED GROUND REFLECTANCE	0.20
ESTIMATED PUMPING POWER (KWH/AFTAC)	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PFED . .	0.93
ESTIMATED INSTALL/LABOR COST (\$/AFTAC) . .	10.07
ESTIMATED HEX COST (\$/FT*2)	5.00
ESTIMATED STORAGE TANK COST (\$/LP STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR)	0.0010

SOLAR ENERGY OPTIMIZATION ANALYSIS 73 DESIGN RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>> DATA MATCH TJ INPUT ID NO. 4232
 QMOD-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSULATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE DEG F	HEATING LOAD BTU/MONTH	DHW LOAD BTU/MONTH	EXTRA-TERRESTRIAL INSULATION		COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	BTU/DAY FT**2	FT**2							
JAN	450.3	1327.8	22.2	0.2709E	08	0.2637E	07	1100.1	1.8C5	0.059	
FEB	681.6	1152.7	24.2	0.2352E	08	0.2382E	07	1548.6	1.538	0.098	
MAR	969.6	1013.4	32.3	0.2307E	08	0.2637E	07	2222.5	1.243	0.152	
APR	1204.0	664.7	42.8	0.1356E	08	0.2552E	07	2953.7	1.037	0.249	
MAY	1567.0	379.9	52.9	0.1750E	07	0.2637E	07	3509.2	0.920	0.413	
JUN	1712.0	118.5	62.7	0.2417E	07	0.2552E	07	3757.2	0.874	0.723	
JUL	1659.0	22.1	68.0	0.4508E	06	0.2637E	07	3643.1	0.895	0.917	
AUG	1401.0	42.0	66.6	0.8568E	06	0.2637E	07	3182.5	0.858	0.858	
SEP	1153.0	202.8	59.0	0.4137E	07	0.2552E	07	2494.3	1.168	0.533	
OCT	822.3	502.1	48.8	0.1024E	08	0.2637E	07	1761.6	1.454	0.270	
NOV	459.2	785.4	38.8	0.1602E	08	0.2552E	07	1205.3	1.673	0.089	
DEC	1199.0	1199.0	26.3	0.2446E	08	0.2637E	07	970.6	1.851	0.043	
TOTAL	3622.8	7410.4		0.1512E	09	0.3105E	08		>>>WEIGHTED AVERAGE	0.155	
>>>OTHER PARAMETERS											

COLLECTOR AREA (FT**2)			>>>	260.13	COLLECTOR SIDE CAPACITY (BTU/HR FT)						0.219E 04
COLLECTOR TILT ANGLE (DEG)			>>>	40.75	STORAGE SIDE CAPACITY (BTU/HR FT)						0.393E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)			>>>	0.0653	COLLECTOR SIDE CONVECTION COEFF.						1.0/1.7600
COLLECTOR SIDE TUBE OUTER DIA. (FT)				0.0729	STORAGE SIDE CONVECTION COEFFICIENT						3853.5100E
STORAGE SIDE TUBE(HX) INNER DIA. (FT)				0.1384	COLLECTOR SIDE FLOW RATE (GPM)						4.4916E
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)				2.9356	STORAGE SIDE FLOW RATE (GPM)						100.6822E
STORAGE SIDE FLUID VELOCITY (FT/SEC)				20.5306	NORMALIZED COLLECTOR FLOW (GPM/AREAC)						0.0172E
HEAT EXCHANGER LENGTH (FT)				94.61	NORMALIZED STORAGE FLOW (GPM/AREAC)						0.384E
HEAT EXCHANGER EFFECTIVENESS					HEAT EXCHANGER EFFECTIVENESS						0.933E
HEX ANNUAL DIAMETER DIFFERENCE (FT)				0.0655	SOLAR ENERGY DELIVERED (BTU/YEAR)						0.354E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)				0.0075	TOTAL ENERGY DEMAND (BTU/YEAR)						0.182E 09
COLLECTOR SIDE REYNOLDS NUMBER				0.497E 03	ANNUAL AVERAGE SOLAR LOAD FRACTION						0.194E
STORAGE SIDE REYNOLDS NUMBER				0.190E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT						>>>
CAPACITY RATIO (CALH/C MAX)				0.0449	HX COEFFICIENT (BTU/HR FT**2)						314.28E
FLOW PARAMETER Z1 (GCP/FRUIT)				0.5361	TOTAL INSTALLATION COST (\$)						5463.0E
FLOW PARAMETER Z1 (GCP/FRUIT)				9.03	COLLECTOR FLOW FACTOR(FPP)						0.946E

S O L U A T I O N

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 4232
IMCD-1 LWK AUGUST 1979

STUDY APPROACH

COLLECTOR FEDERAL POSITION 1. D

MAINE

PORTLAND

LOCATION

ECONOMIC ESTIMATES

COLLECTOR TEST RESULTS,

4

LOCATION INDEX.....

SYSTEM LIFE(YEARS)....
DISCOUNT RATE.....
INFLATION RATE.....

SLOPE:.....
PARAMETER, FRUL.....
INTERCEPT:
PARAMETER, FR TA.....
BASE COST, \$/FT**2.....

LATITUDE, DEGREES.....
MEAN TEMPERATURE.....
INSOL (BTU/DAY FT**2)
LOCAL FACTOR, FDC.....
MEAN GROUND TEMP.....

20.00
0.0900
0.1100

SELECTED PARAMETERS

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE..... HEATING VALUE
INDEX TYPE EFFICIENCY COST.....
1 OIL 0.70 0.70 (\$/GAL) 14200.0 (BTU/GAL)
2 OIL 0.99 0.65 (\$/KWH) 3413.0 (BTU/KWH)
3 GAS 0.70 0.40 (\$/THER) 100000.0 (BTU/THER)

COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(KTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FLOWING FACTOR(HR F/RTU)
STORAGE SIDE FLOWING FACTOR(HR F/RTU)
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORACE(LB/AR*FAC).....
ESTIMATED GLAZED REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AR*FAC).....
ESTIMATED CORRECTION FACTOR TAY ALPHA FRLD.....
ESTIMATED INSTALL/LABOR COST (\$/AR*FAC).....
ESTIMATED HEX COST (\$/FT**2).....
ESTIMATED STORAGE TANK COST(\$/LB STORED)
MAINTENANCE (\$ INSTALLED COST/YR).....

OIL
HEATING VALUE
5000.00
10799.99
140.00
20.00
6.00
1.00

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..
LOAD CONDUCTANCE (BTU/DEG F DAY).....
DOMESTIC HOT WATER (DEG) DESIGN TEMP..
ESTIMATED DAILY HOT WATER USAGE (GAL/PER)..
ESTIMATED HOT WATER USE PER (GAL/PER)..
ESTIMATED STORAGE TO LOAD EFFECTIVENESS..

176.0
60.8
1.000
0.387
104.0
62.0
1.000
0.304
0.001
0.001
220.0
15.0
0.0
1.000
0.0
10.0
5.0
0.00

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH ID INPUT ID NO. 4233
 1990D-1 LMK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/M INTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/EAF FT**2	DEG DAY	DEG F				BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.1434E	08	0.2637E	1100.1	1.757	0.076
FEB	681.6	1152.7	24.2	0.1245E	08	0.2582E	1548.6	1.534	0.126
MAR	969.6	1013.4	32.3	0.1094E	08	0.2637E	2222.9	1.243	0.192
APR	1204.0	664.7	42.8	0.7119E	07	0.2552E	2553.7	1.035	0.302
MAY	1567.0	379.9	52.5	0.4103E	07	0.2637E	3505.2	0.924	0.465
JUN	1712.0	113.5	62.7	0.1231E	07	0.2552E	3757.2	0.878	0.714
JUL	1659.0	22.1	68.0	0.2337E	06	0.2637E	3643.1	0.899	0.847
AUG	1461.0	42.0	66.6	0.4536E	06	0.2637E	3182.5	0.798	0.798
SEP	1158.0	202.8	59.0	0.2190E	07	0.2552E	2494.3	1.149	0.555
OCT	822.3	502.1	48.8	0.5423E	07	0.2637E	1761.6	1.450	0.314
NOV	459.2	785.4	38.8	0.8482E	07	0.2552E	1205.3	1.667	0.109
DEC	362.8	1199.0	26.3	0.1295E	08	0.2637E	970.6	1.841	0.054
TOTAL		7410.4		0.8003E	08	0.3105E		AVERAGE	0.240
OTHER PARAMETERS									
COLLECTOR AREA (FT**2)			>>>	194.39		COLLECTOR SIDE CAPACITY (BTU/HR)		F)	0.164E 0
COLLECTOR TILT ANGLE (DEG)			>>>	40.04		STORAGE SIDE CAPACITY (BTU/HR)		F)	0.369E 0
COLLECTOR SIDE TUBE INNER DIA. (FT)			>>>	0.0557		COLLECTOR SIDE CONVECTION COEFF.			1135.793
COLLECTOR SIDE TUBE OUTER DIA. (FT)				0.0629		STORAGE SIDE CONVECTION COEFFICIENT			3541.906
STORAGE SIDE TUBE (INX) INNER DIA. (FT)				0.1247		COLLECTOR SIDE FLOW RATE (GPM)			3.3703
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)				3.0824		STORAGE SIDE FLOW RATE (GPM)			74.142
STORAGE SIDE FLUID VELOCITY (FT/SEC)				18.1571		NORMALIZED COLLECTOR FLOW (GPM/AREAC)			0.017
HEAT EXCHANGER LENGTH (FT)				60.01		NORMALIZED STORAGE FLOW (GPM/AREAC)			0.390
HEAT EXCHANGER POINTS						HEAT EXCHANGER EFFECTIVENESS			0.9278
HEX ANNUAL DIAMETER DIFFERENCE (FT)				0.0617		SOLAR ENERGY DELIVERED (BTU/YEAR)			0.267E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)				0.0073		TOTAL ENERGY REMAIN (BTU/YEAR)			0.111E 08
COLLECTOR SIDE PLYTHOS NUMBER				0.438E 05		ANNUAL AVERAGE SOLAR LOAD FRACTION			0.2405
STORAGE SIDE CYLINDR NUMBER				0.158E 06		OBJECTIVE: NPV OF SOLAR INVESTMENT			>>>
CAPACITY RATE (CMIG/L MAX)				0.0445		HEX COEFFICIENT (BTU/HP FT**2)			0.146E 08
FLOW PARAMETER Z1(COP/FRUL)				9.5527		TOTAL INSTALLATION COST (\$)			4039.3
FLOW PARAMETER Z1(COP/FRPH)				9.534		COLLECTOR FLOW FACTOR (FPP)			0.546

>>>>DATA MATCH TO OUTPUT ID NC. 9111
IMTD-1 LWK AUGUST 1975

LOCATION	OAKLAND	CALIF.	COLLECTOR SOLARMETRICS	STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES					
LOCATION INDEX.....		9	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....		37.73	SLOPE:		
MEAN TEMPERATURE.....		56.59	PARAMETER, FRUL....	1.0380	
INSOL (BTU/DAY FT#2).....		1535.21	INTERCEPT:		
LCAC FACTOR, HCL.....		3145.40	PARAMETER, FR TA....	0.6910	20.00
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT #2...	12.98	0.1150
					0.1050

TYPE ENERGY BASE	INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE	U/L
OIL	1		0.70	0.90 (\$/GAL)	14200.0 (BTU/GAL)	
ELE	2		0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
GAS	3		0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	

HEAT LOAD CHARACTERISTICS	
LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.25
LOAD SURFACE FEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	30000.00
DOMESTIC HOT WATER (GPM) DESIGN TEMP.	140.00
ESTIMATED DAILY LHW USAGE (GAL/PER)	20.00
ESTIMATED DWL USERS (PER) ..	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS ..	1.00

COLLECTOR	FLUID	MEAN TEMPERATURE	COLLECTOR	FLUID	MEAN TEMPERATURE
COLLECTOR	FLUID DENSITY (LB/FT**3) ..	176.00	COLLECTOR	FLUID DENSITY (LB/FT**3) ..	60.81
COLLECTOR	FLUID SPECIFIC HEAT (BTU/LR*F) ..	1.0000	COLLECTOR	FLUID SPECIFIC HEAT (BTU/LR*F) ..	1.0000
COLLECTOR	FLUID CONDUCTIVITY (BTU/LR*FT*F) ..	0.3640	COLLECTOR	FLUID CONDUCTIVITY (BTU/LR*FT*F) ..	0.3870
STORAGE	FLUID MEAN TEMPERATURE ..	104.00	STORAGE	FLUID MEAN TEMPERATURE ..	104.00
STORAGE	FLUID DENSITY (LB/FT**3) ..	62.09	STORAGE	FLUID DENSITY (LB/FT**3) ..	62.09
STORAGE	FLUID SPECIFIC HEAT (BTU/LB*F) ..	1.0000	STORAGE	FLUID SPECIFIC HEAT (BTU/LB*F) ..	1.0000
STORAGE	FLUID CONDUCTIVITY (BTU/LR*FT*F) ..	0.3640	STORAGE	FLUID CONDUCTIVITY (BTU/LR*FT*F) ..	0.3640
COLLECTOR	SIDE FOULING FACTOR (HR F/RTU) ..	0.0010	COLLECTOR	SIDE FOULING FACTOR (HR F/RTU) ..	0.0010
STORAGE	SIDE FOULING FACTOR (HR F/RTU) ..	0.0010	STORAGE	SIDE FOULING FACTOR (HR F/RTU) ..	0.0010
HEX TUBE	CONDUCTIVITY (BTU/HR FT F) ..	220.00	HEX TUBE	CONDUCTIVITY (BTU/HR FT F) ..	220.00
ESTIMATED	OPTIMUM STORAGE (LB/AREAC) ..	15.30	ESTIMATED	OPTIMUM STORAGE (LB/AREAC) ..	15.30
ESTIMATED	GROUND REFLECTANCE ..	0.20	ESTIMATED	GROUND REFLECTANCE ..	0.20
ESTIMATED	PUMPING POWER (KWF/AREAC) ..	1.0000	ESTIMATED	PUMPING POWER (KWF/AREAC) ..	1.0000
ESTIMATED	CORRECTION FOR TAU ALPHA PREC.	0.93	ESTIMATED	CORRECTION FOR TAU ALPHA PREC.	0.93
ESTIMATED	INSTALL/LABOR COST (\$/AREAC) ..	10.00	ESTIMATED	INSTALL/LABOR COST (\$/AREAC) ..	10.00
ESTIMATED	HEX COST (\$/FT**2) ..	5.00	ESTIMATED	HEX COST (\$/FT**2) ..	5.00
ESTIMATED	STORAGE TANK COST (\$/LB STORED) ..	0.08	ESTIMATED	STORAGE TANK COST (\$/LB STORED) ..	0.08
MAINTENANCE	(\$ INSTALLED COST/YR) ..	0.01	MAINTENANCE	(\$ INSTALLED COST/YR) ..	0.01

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS DR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>> DATA MATCH TC INPUT ID NO. 9111

OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	107.9	518.2	48.3	0.1555E 08	0.2637E 07	1407.4	1.639	0.160
FEB	1017.4	376.5	51.7	0.1130E 08	0.2382E 07	1838.5	1.448	0.263
MAR	1456.3	370.3	53.1	0.1111E 08	0.2637E 07	2458.1	1.222	0.360
APR	1922.1	291.5	55.3	0.8745E 07	0.2552E 07	3095.3	1.034	0.467
MAY	2211.3	222.0	58.0	0.6660E 07	0.2637E 07	3553.7	0.915	0.570
JUN	2250.0	138.2	61.0	0.4146E 07	0.2552E 07	3750.2	0.867	0.708
JUL	2322.5	110.2	61.8	0.3306E 07	0.2637E 07	3660.4	0.889	0.787
AUG	2052.6	91.2	62.4	0.2730E 07	0.2637E 07	3287.3	0.983	0.819
SEP	1701.2	75.6	63.4	0.2268E 07	0.2552E 07	2698.9	1.153	0.835
OCT	1212.0	151.3	60.4	0.4539E 07	0.2637E 07	2037.5	1.383	0.572
NOV	822.2	307.4	54.6	0.9222E 07	0.2552E 07	1510.1	1.613	0.281
DEC	647.0	493.0	49.1	0.1475E 08	0.2637E 07	1279.6	1.725	0.158
TOTAL		3145.4		0.9436E 08	0.3105E 08	>>>WEIGHTED AVERAGE		0.359

DESIGN VARIABLES/CONSTRAINTS			OTHER PARAMETERS			
COLLECTOR AREA	(FT**2)	>>>	202.53	COLLECTOR SIDE CAPACITY	(BTU/HR F)	0.205E 04
COLLECTOR TILT ANGLE	(DEG)	>>>	35.27	STORAGE SIDE CAPACITY	(BTU/HR F)	0.466E 05
COLLECTOR SIDE TUBE INNER DIA.	(FT)	>>>	0.0634	COLLECTOR SIDE CONVECTION COEFF.		1075.9285
COLLECTOR SIDE TUBE OUTER DIA.	(FT)		0.0698	STORAGE SIDE CONVECTION COEFFICIENT		3792.2302
STORAGE SIDE TUBE(HEX) INNER DIA.	(FT)		0.1347	COLLECTOR SIDE FLOW RATE	(GPM)	4.2100
COLLECTOR SIDE FLUID VELOCITY	(FT/SEC)		2.9750	STORAGE SIDE FLOW RATE	(GPM)	93.6330
STORAGE SIDE FLUID VELOCITY	(FT/SEC)		20.0411	NORMALIZED COLLECTOR FLOW	(GPM/AREAC)	0.0208
HEAT EXCHANGER LENGTH	(FT)		33.08	NORMALIZED STORAGE FLOW	(GPM/AREAC)	0.4623
HEAT EXCHANGER DIAMETER	(FT)	CONSTRAINTS		HEAT EXCHANGER EFFECTIVENESS		0.9262
HEX ANNULAR DIAMETER DIFFERENCE	(FT)		0.0640	SOLAR ENERGY DELIVERED	(BTU/YEAR)	0.500E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE	(FT)		0.0065	TOTAL ENERGY DEMAND	(BTU/YEAR)	0.125E 09
COLLECTOR SIDE REYNOLDS NUMBER			0.481E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION		0.3988
STORAGE SIDE REYNOLDS NUMBER			0.183E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT		0.217E 04
CAPACITY RATIO	(CMIN/C MAX)		0.0440	HEX COEFFICIENT	(BTU/HR F FT**2)	314.20
FLOW PARAMETER Z1(CCP/FPHL)			9.7676	TOTAL INSTALLATION COST (\$)		6083.24
FLOW PARAMETER Z1(GC/P/FPHL)			9.20	COLLECTOR FLOW FACTOR(FPP)		0.9479


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S U L D A D - I
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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DESIGN DATA OPTIONS/_INPUTS SUMMARY
**          **          **          **          **          **          **          **
>>>>DATA MATCH TO OUTPUT ID NO: 9112
IMOD-1 LWK AUGUST 1979

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SIMILAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MARCH TO OUTPUT ID NO. 9112
IMOD-1 LNK AUGUST 1979

LOCATION	OAKLAND	CALIF.	COLLECTOR SOLAR ANGLES	STUDY APPROACH	ANALYSIS
COLLECTOR TEST RESULTS,					
LOCATION INDEX.....		9	SLOPE:		
LATITUDE, DEGREES.....		37.73	PARAMETER, FRUL....		
MEAN TEMPERATURE.....		56.59	INTERCEPT:		
INSUL (B TL/DAY FT**2)		1535.21	PARAMETER, FRTA....		20.00
LOAD FACTOR, H/D.....		3145.40	BASE COST, \$/FT**2...		0.1150
MEAN GROUND TEMP.....		55.00			0.1050
ECONOMIC ESTIMATES					
SYSTEM LIFE (YEARS)...					
DISCOUNT RATE.....					
INFLATION RATE.....					

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASIS	EFFICIENCY	COST	HEATING VALUE	UNIT
1	CIL		0.70	0.90 (\$/GAL)	142000.0	(BTU/GAL)
2	ELE		0.99	0.05 (\$/KWH)	3413.0	(BTU/KWH)
3	GAS		0.70	0.40 (\$/THERM)	100000.0	(BTU/THERM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HK F (FT**2) F1*2)
 LULCAL SURFACE HEAT TRANSFER AREA (FT**2)
 LULCAL CONDUCTANCE (BTU/DEG F DAY)
 DOMESTIC HOT WATER (DHW) DESIGN TEMP
 ESTIMATED DAILY THW USAGE (GAL/PLR)
 ESTIMATED DHW USERS (PEP)
 ESTIMATED STORAGE T LOAD EFFECTIVENESS

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT*3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT*3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).....
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)
STORAGE SIDE FOULING FACTOR(HR F/BTU)
HEX TUBE CONDUCTIVITY(BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE(LB/APAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PPED.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED FIX COST ($/FT*2).....
ESTIMATED STORAGE TANK COST($/LF STORED).....
MAINTENANCE (% INSTALLED COST/YR).....

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STUDY APPROACH

ECONOMIC ESTIMATES

SYSTEM LIFE (YEARS)
DISCOUNT RATE
INFLATION RATE

—

176.00
66.81
1.0000
0.3870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
10.00
5.00
0.08
0.01

S O L A R - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>DATA MATCH TO INPUT 10 NO. 9112
MODEL-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.1057E 08	0.2637E 07	1407.4	1.641	0.171
FEB	1017.4	376.5	51.7	0.7681E 07	0.2382E 07	1838.5	1.449	0.277
MAR	1456.3	370.3	53.1	0.7554E 07	0.2637E 07	2458.1	1.223	0.376
APR	1922.1	291.5	55.3	0.5947E 07	0.2552E 07	3095.3	1.033	0.481
MAY	2211.3	222.0	58.0	0.4529E 07	0.2637E 07	3553.7	0.915	0.575
JUN	2350.0	138.2	61.0	0.2817E 07	0.2552E 07	3750.2	0.866	0.656
JUL	2322.5	110.2	61.8	0.2248E 07	0.2637E 07	3660.4	0.888	0.764
AUG	2052.6	91.2	62.4	0.1800E 07	0.2637E 07	3287.3	0.982	0.783
SEP	1701.2	75.6	63.4	0.1542E 07	0.2552E 07	2698.9	1.153	0.798
OCT	1212.0	151.3	60.4	0.3087E 07	0.2637E 07	2037.5	1.384	0.564
NOV	822.2	307.4	54.6	0.6271E 07	0.2552E 07	1510.1	1.614	0.292
DEC	647.0	455.0	49.1	0.1006E 08	0.2637E 07	1279.6	1.727	0.168
TOTAL		3145.4		0.6417E 08	0.3105E 08		AVERAGE	0.413

>>>WEIGHTED
OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS	COLLECTOR SIDE CAPACITY (BTU/HR F)	STORAGE SIDE CAPACITY (BTU/HR F)	COLLECTOR SIDE CONVECTION COEFF	STORAGE SIDE CONVECTION COEFFICIENT	COLLECTOR SIDE FLOW RATE (GPM)	STORAGE SIDE FLOW RATE (GPM)	NORMALIZED STORAGE FLOW (GPM/AREAC)	HEAT EXCHANGER EFFECTIVENESS	SOLAR ENERGY DELIVERED (BTU/YEAR)	TOTAL ENERGY DEMAND (BTU/YEAR)	ANNUAL AVERAGE SOLAR LOAD FRACTION	OBJECTIVE: NPV OF SOLAR INVESTMENT	HEX COEFFICIENT (BTU/HR F FT**2)	TOTAL INSTALLATION COST (\$)	COLLECTOR FLOW FACTOR(FPP)
COLLECTOR AREA (FT**2)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
COLLECTOR TILT ANGLE (DEG)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
HEAT EXCHANGER LENGTH (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
HEAT EXCHANGER LAYOUT/CONSTRAINTS	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
HEX ANNULAR DIAMETER DIFFERENCE (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
COLLECTOR SIDE REYNOLDS NUMBER	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
STORAGE SIDE REYNOLDS NUMBER	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
CAPACITY RATIO (GAL/CMAX)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
FLOW PARAMETER Z2(CCP/FOUL)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
FLOW PARAMETER Z1(GCP/FRPUL)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>



DESIGN ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH TO OUTPUT ID NO. 9113
IMUD-1 LWK AUGUST 1979

LOCATION	OAKLAND	CALIF.	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS

LOCATION INDEX.....	9		COLLECTOR TEST RESULTS,		
LATITUDE DEGREES.....	37.73		SLOPE:		
MEAN TEMPERATURE.....	56.59		PARAMETER, FRUL....		
INSOL (BTU/DAY FT**2)	1535.21		INTERCEPT:		
CALC FACTOR, FDC.....	3145.40		PARAMETER, FR TA....		
MEAN GKLAND TEMP.....	55.00		BASE COST, \$/FT**2...		

			ECONOMIC ESTIMATES	-----	
			SYSTEM LIFE(YEARS)...	20.00	
			DISCOUNT RATE	0.1150	
			INFLATION RATE.....	C.1050	

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90 (\$/GAL)	14200.0 (BTU/GAL)	
2	ELF	0.59	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	

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COLLECTOR FLOW MEAN TEMPERATURE.....
COLLECTOR FLOW DENSITY (LB/FT**3).....
COLLECTOR FLOW SPECIFIC HEAT (BTU/LB*F).....
COLLECTOR FLOW CONDUCTIVITY (BTU/FR*FT*F)
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY (LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT (BTU/LB*F).....
STORAGE FLOW CONDUCTIVITY (BTU/HR FT F).....
COLLECTOR SIDE FOULING FACTOR (FR F/FTU)
STORAGE SIDE FOULING FACTOR (HR F/FTU)
HEX CORE CONDUCTIVITY (RTU/FR FT F).....
ESTIMATED OPTIMUM STORAGE (LB/AREAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER (KW/HR LAC).....
ESTIMATED CORRECTION FOR TAU ALPHA FREQ.....
ESTIMATED INSTALL/LABOR COST ($/AREAC).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST ($/LP STORED)
ESTIMATED MAINTENANCE ($ INSTALLED COST/YR).....

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LOAD LOSS COEFFICIENT (BTU/HR * FT**2) ..	0.09
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG * DAY) (FT**2) ..	10799.99
DOMESTIC FIT WATER (CFW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW USERS (PER) ..	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS ..	1.00

176.00
60.81
1.0000
0.2870
104.09
62.09
1.0000
0.3640
0.0010
0.0010
226.00
15.30
0.20
1.0000
0.93
10.00
5.00
0.08
0.01



SULLYAD-1

TTC INPUT ID NO. 9113
COMOD-1 LNK AUGUST 1979

>>>WEIGHTED AVERAGE

>>>WEIGHTED
OTHER PARAMETERS



>>>>> DATA MATCH TO OUTPUT ID NO. 9213
IMCD-1 LMK AUGUST 1979

SELECTED PARAMETERS

134



SOLAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN
RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>> DATA MARCH TC INPUT ID NO. 9213
QUCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT*2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY	FT*2		
JAN	107.9	518.2	48.3	0.5597E 07	0.2637E 07	1407.4		1.668	0.316
FEB	1017.4	370.5	51.7	0.4060E 07	0.2382E 07	1838.5		1.464	0.476
MAR	1456.3	370.3	53.1	0.3099E 07	0.2637E 07	2458.1		1.225	0.610
APR	1922.1	291.5	55.3	0.3148E 07	0.2552E 07	3095.3		1.025	0.728
MAY	2211.3	222.0	58.0	0.2398E 07	0.2637E 07	3553.7		0.900	0.808
JUN	2350.0	138.2	61.0	0.1493E 07	0.2552E 07	3750.2		0.850	0.853
JUL	2322.5	110.2	61.8	0.1190E 07	0.2637E 07	3660.4		0.872	0.937
AUG	2052.6	91.2	62.4	0.9350E 06	0.2637E 07	3287.3		0.971	0.947
SEP	1701.2	75.6	63.4	0.8165E 06	0.2552E 07	2698.9		1.151	0.951
OCT	1212.0	151.3	60.4	0.1634E 07	0.2637E 07	2037.5		1.355	0.775
NOV	822.2	307.4	54.6	0.3320E 07	0.2552E 07	1510.1		1.639	0.484
DEC	647.0	453.0	49.1	0.5324E 07	0.2637E 07	1279.6		1.759	0.310
TOTAL		3145.4		0.3397E 08	0.3105E 08	>>>	WEIGHTED AVERAGE		0.621

DESIGN VARIABLES/CONSTRAINTS						OTHER PARAMETERS					
COLLECTOR AREA	(FT**2)				>>>	192.13	COLLECTOR SIDE CAPACITY (BTU/HR F)				0.195E 04
TILT ANGLE	(DEG)				>>>	37.79	STORAGE SIDE CAPACITY (BTU/HR F)				0.365E 05
COLLECTOR TUBE INNER DIA.	(FT)				>>>	0.0373	COLLECTOR SIDE CONVECTION COEFF.				1228.0464
COLLECTOR TUBE OUTER DIA.	(FT)					0.0630	STORAGE SIDE CONVECTION COEFFICIENT				3488.8645
STORAGE SIDE TUBESHEX INNER DIA.	(FT)					0.1250	COLLECTOR SIDE FLOW RATE (GPM)				4.0042
COLLECTOR SIDE FLUID VELOCITY	(FT/SEC)					3.4578	STORAGE SIDE FLOW RATE (GPM)				73.3488
STORAGE SIDE FLUID VELOCITY	(FT/SEC)					17.8583	NORMALIZED COLLECTOR FLOW (GPM/AREAC)				0.0208
HEAT EXCHANGER LENGTH	(FT)					31.71	NORMALIZED STORAGE FLOW (GPM/AREAC)				0.3818
CONSTRAINTS	/				/		HEAT EXCHANGE EFFECTIVENESS				0.9060
DIAPHETEN DIFFERENCE	(FT)				/	0.0620	SOLAR ENERGY DELIVERED (BTU/YEAR)				0.404E 08
COLLECTOR SLOPE TUBE DIA. DIFFERENCE	(FT)				/	0.0057	TOTAL ENERGY DEMAND (BTU/YEAR)				0.650E 08
COLLECTOR SLOPE TUBE DIA. NUMBER					/	0.006 05	ANNUAL AVERAGE SOLAR LOAD FRACTION				0.0210
COLLECTOR SLOPE TUBE DIA. MAXIMUM					/	0.156E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT				>>>
CAPACITY RATIO (MIN/MAX)					/	0.0535	MIX COEFFICIENT (BTU/HR FT**2)				0.383E 04
FLOW PARAMETER Z1 (GPM/INPUL)					/	9.7934	TOTAL INSTALLATION COST (\$)				324.59
FLOW PARAMETER Z1 (GCF/INPUL)					/	9.28	COLLECTOR FLOW FACTOR(FPP)				4723.78
					/						0.5480



5717-1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO CLTPTUT ID NC. 9221
(M00)-1 LWK AUGUST 1979

LOCATION	LANLAD	CALIF.	COLLECTOR AMERICAN SUR	STUDY APPROACH	ANALYST
LOCATION INDEX.....		9	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....		37.73	SLOPE:		
MEAN TEMPERATURE.....		56.59	PARA FLEX, FRUL.....	SYSTEM LIFE (YEARS)...	20.00
INSOL (BTU/DAY FT**2)		1535.21	INTERCEPT:	DISCOUNT RATE.....	0.0900
LOCAL FACTOR, FLE.....		3145.40	PARA FLEX, FRIA.....	INFLATION RATE.....	0.1100
MEAN SECOND TEMP.....		55.00	BASE COST, \$/FT**2....		

ENERGY COMPARATIVE ESTIMATES

INDEX	TYPE	ENERGY	BASE	EFF	ICL	ELEC	CO2	HEATING	VAL	OIL
1	GIL	0.70	0.90	(4/0.2L)	1.7	0.00	0.0	(RTU/SAL)		
2	FLF	0.99	0.65	(4/KWH)	3.4	13.0	(3TU/NW1)			
3	GAS	0.73	0.40	(4/TF)	10	0.00	0.0	(3TU/TF4)		

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LOAD LOSS	CORRECTION (QTU/HP - F1*2)	0.25
LOAD SURFACE AREA	TRANSFER AREA (F1*2)	5000.00
LOAD CONDUCTANCE	BTU/DEG F DAY	30000.00
COMPUTED FACTOR	DEBTY HP	140.00
ESTIMATED DAILY WATER USE	(GAL/PER)	20.00
ESTIMATED DEBTY USE	(DEG)	6.00
ESTIMATED THERMAL	LOAD EFFICIENCY	1.00

SELECTED PAPERS

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COLLECTOR FLUID ALERT TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(RTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F)
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID CENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT (RTU/LB*F).....
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F).....
COLLECTOR SIDE COILING FACTOR (LB F/RTU)
STORAGE SIDE COILING FACTOR (LB F/RTU)
HEX FUEL CONDUCTIVITY (BTU/HR*FT*F).....
ESTIMATED OPTICAL STORAGE (LB/AF*AC).....
ESTIMATED ALUMO REFLECTANCE.....
ESTIMATED PUMPING POWER (KW/H*AF*AC).....
ESTIMATED CORRECTION FOR TAIL ALPHA EFFECT
ESTIMATED INSTALLED MOTOR CVT (4/AF*AC).....
ESTIMATED HEX CVT (LB/FT**2)
ESTIMATED STORAGE TANK COST (B/LB STORED)
MAIN TAIL C (4 INSTALLED CVT/YR).....

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SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>> DATA MATCH TO INPUT ID NO. 9221
 0000-1 LWK AUGUST 1979

MONTH	HORIZONTA INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/EAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/EAY FT**2			
JAN	177.9	513.2	48.3	0.1555E 08	0.2637E C7	1407.4	1.653	1.478	0.283
FEB	1617.4	376.5	51.7	0.1130E 08	0.2382E C7	1838.5	1.478	1.225	0.44E
MAR	1456.3	370.3	53.1	0.1111E 08	0.2637E C7	2458.1	1.225	1.015	0.580
APR	1922.1	231.5	55.3	0.3745E 07	0.2552E C7	3095.2	1.015	0.884	0.708
MAY	2211.3	222.0	58.0	0.5600E 07	0.2637E C7	3553.7	0.884	0.831	0.811
JUN	2350.0	138.2	61.0	0.4145E 07	0.2552E C7	3750.2	0.831	0.854	0.826
JUL	2325.5	110.2	61.8	0.3306E 07	0.2637E C7	3660.4	0.854	0.958	0.976
AUG	2655.6	91.2	62.4	0.2735E 07	0.2637E C7	3287.3	0.958	1.147	0.953
SEP	1701.2	75.6	63.4	0.2268E 07	0.2552E C7	2698.9	1.147	1.405	1.000
OCT	1212.0	151.3	60.4	0.4335E 07	0.2637E C7	2637.5	1.405	1.663	0.827
NOV	822.2	307.4	54.6	0.9222E 07	0.2552E C7	1510.1	1.663	1.750	0.474
DEC	677.0	493.0	49.1	0.1475E 08	0.2637E C7	1270.6	1.750		0.281
TOTAL		3145.4		0.9436E 08	0.3105E 08		>>>WEIGHTED AVERAGE		0.584

DESIGN VARIABLES/CONSTRAINTS

OTHER PARAMETERS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIZE CAPACITY (BTU/HR FT)	0.424E 04
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIZE CAPACITY (STU/HR FT)	0.510E 05
COLLECTOR STOR TUBE INER DIA. (FT)	>>>	COLLECTOR SIZE CONVECTION COEFFICIENT	1289.9515
COLLECTOR STOR TUBE OUT. DIA. (FT)		STORAGE SIZE CONVECTION COEFFICIENT	3671.7405
STORAGE SIZE TUBE(OUT) INER DIA. (FT)		COLLECTOR SIZE FLOW RATE (GPM)	1.6278
COLLECTOR SIZE TUBE VOLUME (FT**3)		STORAGE SIZE FLOW RATE (GPM)	102.3935
STORAGE SIZE TUBE VELOCITY (FT/SEC)		NO. TUBES/FT COLLECTOR FLOW (GPM/AREA)	0.2406
HEAT EXCHANGER FLOW (GPM)		HEAT EXCHANGER FLOW (GPM/AREA)	0.2428
HEAT EXCHANGER COLLECTOR FLOW (GPM/AREA)		HEAT EXCHANGER FLOW (GPM/AREA)	0.743E 08
HEAT EXCHANGER DIFFERENCE (FT)		TOTAL ENERGY DEMAND (BTU/EA)	0.125E 09
COLLECTOR SIZE TUBE DIA. DIFFERENCE (FT)		STORAGE SIZE SOLAR FLOW FRACTION	0.504
COLLECTOR SIZE TUBE DIA. DIFFERENCE (FT)		STORAGE SIZE SOLAR FLOW FRACTION	0.78E 04
STORAGE SIZE TUBE DIA. DIFFERENCE (FT)		HEAT EXCHANGER FLOW FRACTION	328.73
CAPACITY RATE (GPM/HR)		TOTAL FLOW FRACTION (FT**2)	700C.09
FLOW PARAMETER 2 (GPM/HR)		COLLECTOR FLOW FRACTION (FT**2)	0.9174





SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>> DATA MATCH TO INPUT ID NO. 9222
JMC0-1 LMK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DM LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	513.2	48.3	0.1057E 03	0.2637E 07	1407.4	1.688	0.305
FEB	1017.4	376.5	51.7	0.7681E 07	0.2382E 07	1838.5	1.476	0.471
MAR	1456.3	370.3	53.1	0.7554E 07	0.2637E 07	2458.1	1.225	0.608
APR	1522.1	291.5	55.3	0.5947E 07	0.2552E 07	3095.3	1.017	0.733
MAY	2211.3	222.0	58.0	0.4529E 07	0.2637E 07	3553.7	0.887	0.825
JUN	2356.0	133.2	61.0	0.2819E 07	0.2552E 07	3750.2	0.835	0.924
JUL	2322.5	110.2	61.8	0.2248E 07	0.2637E 07	3660.4	0.858	0.970
AUG	2052.6	91.2	62.4	0.1800E 07	0.2637E 07	3287.3	0.961	0.984
SEP	1701.2	75.6	63.4	0.1542E 07	0.2552E 07	2698.9	1.148	0.993
OCT	1212.0	151.3	60.4	0.3087E 07	0.2637E 07	2037.5	1.403	0.824
NOV	827.2	307.4	54.6	0.6271E 07	0.2552E 07	1510.1	1.655	0.553
DEC	647.0	453.0	49.1	0.1006E 03	0.2637E 07	1279.6	1.784	0.301
TOTAL	3145.4			0.6417E 08	0.3105E 08		AVERAGE	0.611

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2)	COLLECTOR TILT (DEG)	CAPACITY (BTU/HK F)	COLLECTOR TILT (F)
>>>	>>>	0.338E 04	0.432E 05
COLLECTOR TUBE INNER DIA. (FT)	COLLECTOR TUBE OUTER DIA. (FT)	1286.5342	3565.4451
COLLECTOR TUBE THICK DIA. (FT)	COLLECTOR TUBE FLUID DIA. (FT)	6.9361	60.8246
COLLECTOR TUBE FLUID VELOCITY (FT/SEC)	COLLECTOR TUBE FLUID VELOCITY (FT/SEC)	0.0208	0.2602
HEAT EXCHANGER LENGTH (FT)	HEAT EXCHANGER EFFICIENCY (F)	0.8213	0.582E 03
HEAT EXCHANGER DIA. (FT)	HEAT EXCHANGER DIA. (FT)	0.952E 03	1.6111
COLLECTOR TUBE DIA. DIFFERENCE (FT)	COLLECTOR TUBE DIA. DIFFERENCE (FT)	0.625E 04	327.82
COLLECTOR TUBE REYNOLDS NUMBER	COLLECTOR TUBE REYNOLDS NUMBER	6024.39	0.9478
STORAGE CAPACITY RATE (GAL/HR)	STORAGE CAPACITY RATE (GAL/HR)		
FLOW PARAMETER 1 (GAL/HR)	FLOW PARAMETER 1 (GAL/HR)		
FLOW PARAMETER 2 (GAL/HR)	FLOW PARAMETER 2 (GAL/HR)		



S O L I D - I
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH *****
IMOD-1 LWC AUGUST 1975 9223

LOCATION	OAKLAND	CALIF.	COLLECTOR AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....	9		COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....	37.13		SLOPE:		
MEAN TEMPERATURE.....	56.59		PARAMETER, FRU.....		20.00
INSOL (BTU/DAY FT**2)	1935.21		INTERCEPT:	SYSTEM LIFE(YEARS)...	0.0900
LOAD FACTOR, HLL.....	3145.40		PARAMETER, FRTA.....	DISCOUNT RATE.....	0.1100
MEAN GROUND TEMP.....	55.00		BASE COST, \$/FT**2:...	INFLATION RATE.....	

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE.....	EFFICIENCY	COST	HEATING VALUE	OIL
INDEX TYPE				VALUE
1 OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	176.00
2 ELE	0.59	0.05 (\$/KWH)	3413.0 (BTU/KWH)	60.81
3 GAS	0.70	0.40 (\$/THER)	100000.0 (BTU/THER)	1.0000
HEAT LOAD CHARACTERISTICS				0.3640
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)...				0.0010
LOAD SURFACE HEAT TRANSFER AREA (FT**2)...				220.00
LOAD CONDUCTANCE (BTU/DEG F DAY)...				15.30
DOMESTIC HOT WATER (DHW) DESIGN TEMP.....				0.20
ESTIMATED DAILY DHW USAGE (GAL/PER)...				1.0000
ESTIMATED DHW USERS (PER).....				0.03
ESTIMATED STORAGE TANK COST (\$/LBS STORPED)				10.00
MAINTENANCE (% INSTALLED COST/YR).....				5.00
				0.08
				0.0100



SOLAR ENERGY OPTIMIZATION ANALYSIS IR DESIGN

RESULTS OF ANALYSIS FOR TARKLAND CALIF.

>>>>DATA MARK T1 INPUT ID NO. 9223
OMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DM LOAD	EXTRA- THERMAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.5597E 07	0.2637E 07	1407.4	1.680	0.341
FEB	1017.4	376.5	51.7	0.4066E 07	0.2382E 07	1838.5	1.471	0.512
MAR	1456.3	370.3	53.1	0.3999E 07	0.2037E 07	2458.1	1.225	0.650
APR	1522.1	291.5	55.3	0.3148E 07	0.2552E 07	3095.3	1.020	0.765
MAY	2241.3	222.0	58.0	0.2398E 07	0.2637E 07	3553.7	0.893	0.839
JUN	2350.0	138.2	61.0	0.1493E 07	0.2652E 07	3750.2	0.841	0.914
JUL	2322.5	110.2	61.8	0.1190E 07	0.2637E 07	3660.4	0.864	0.954
AUG	2052.6	91.2	62.4	0.9850E 06	0.2637E 07	3287.3	0.965	0.961
SEP	1701.2	75.6	63.4	0.3155E 06	0.2552E 07	2698.9	1.145	0.966
OCT	1212.0	151.3	60.4	0.1634E 07	0.2637E 07	2037.5	1.400	0.809
NOV	822.2	307.4	54.6	0.3320E 07	0.2552E 07	1510.1	1.651	0.515
DEC	647.0	493.0	49.1	0.5324E 07	0.2637E 07	1279.6	1.774	0.334
TOTAL		3145.4		0.5397E 08	0.3105E 08			0.650

DESIGN PARAMETERS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2)	COLLECTOR TILT (DEG)	CAPACITY (BTU/HR)	EFFICIENCY (F)
1017.4	376.5	1838.5	0.444E 04
1456.3	370.3	2458.1	0.444E 05
1522.1	291.5	3095.3	1.026E 08
2241.3	222.0	3553.7	3.691E 32
2350.0	138.2	3750.2	5.046E 02
2322.5	110.2	3660.4	8.914E 01
2052.6	91.2	3287.3	0.021E 01
1701.2	75.6	2698.9	0.372E 01
1212.0	151.3	2037.5	0.423E 08
822.2	307.4	1510.1	0.650E 08
647.0	493.0	1279.6	0.649E 04
			3.05E 07
			1.32E 74
			0.948E 06



116.00
50.31
1.0000
0.3870
104.00
52.09
1.0000
0.3640
0.0010
0.0010
226.00
15.00
0.2000
1.0000
0.9300
10.0000
15.0000
0.0800
0.0010



SOLAR EFFICIENCY OPTIMIZATION ANALYSIS OF DESIGN RESULTS OF ANALYSIS FOR OAKLAND CALIF.

RESULTS OF ANALYSIS FOR DAKI AND CALIF.

>>>>DATA MATCH TO INPUT ID NO. 9231
JULY-11 WK AUGUST 1975

1979 AUGUST 15 1041 AM - 1 WK

MONTH	FOR LITHA INSULATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE		HEATING LOAD		OHW LOAD		FAKRA- TERRESTRIAL INSULATION		COLLECTOR TILT FACTOR		SOLAR ENERGY EFFECTIVENESS	
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/AMPTH	BTU/MINUTE	BTU/DAY FT**2	BTU/AMPTH	BTU/MINUTE	BTU/DAY FT**2	BTU/AMPTH	BTU/DAY FT**2	BTU/AMPTH	BTU/DAY FT**2	BTU/AMPTH	BTU/DAY FT**2	BTU/AMPTH
JAN	707.9	518.2	48.3	0.1555E	0.2637E	0.8	1407.4	0.2637E	0.7	1.653	0.274	0.274	0.274	0.274	0.274	0.274
FEB	1017.4	376.5	51.7	0.1130E	0.2382E	0.8	1338.5	0.2382E	0.7	1.478	0.425	0.425	0.425	0.425	0.425	0.425
MAR	1459.3	370.5	53.1	0.1111E	0.2537E	0.8	2458.1	0.2537E	0.7	1.225	0.553	0.553	0.553	0.553	0.553	0.553
APR	1922.1	291.5	55.3	0.8745E	0.2552E	0.7	3955.3	0.2552E	0.7	1.015	0.680	0.680	0.680	0.680	0.680	0.680
MAY	2211.3	222.0	58.0	0.6560E	0.2637E	0.7	3553.7	0.2637E	0.7	0.884	0.788	0.788	0.788	0.788	0.788	0.788
JUN	2351.0	138.2	61.0	0.4146E	0.2552E	0.7	3750.2	0.2552E	0.7	0.831	0.919	0.919	0.919	0.919	0.919	0.919
JUL	2222.5	110.2	61.8	0.3300E	0.2637E	0.7	3660.4	0.2637E	0.7	0.955	0.983	0.983	0.983	0.983	0.983	0.983
AUG	2052.0	91.2	62.4	0.2738E	0.2637E	0.7	3287.3	0.2637E	0.7	0.958	1.000	1.000	1.000	1.000	1.000	1.000
SEP	1701.2	75.0	63.4	0.2268E	0.2552E	0.7	2698.9	0.2552E	0.7	1.147	0.814	0.814	0.814	0.814	0.814	0.814
OCT	1212.0	151.3	60.4	0.4539E	0.2637E	0.7	2037.5	0.2637E	0.7	1.405	0.956	0.956	0.956	0.956	0.956	0.956
NOV	822.2	307.4	54.6	0.9222E	0.2552E	0.7	1510.1	0.2552E	0.7	1.663	0.272	0.272	0.272	0.272	0.272	0.272
DEC	647.0	493.0	49.1	0.1479E	0.2637E	0.8	1279.6	0.2637E	0.8	1.789	0.571	0.571	0.571	0.571	0.571	0.571
TOTAL	1455.4															
<div style="display: flex; justify-content: space-between;"> <div> <p>DESIGN VARIABLES/CONSTRAINTS</p> <hr/> <p>COLLECTOR AREA (FT**2) >>></p> <p>COLLECTOR TILT (DEG) >>></p> <p>COLLECTOR SIDE TUBE INLET DIA. (FT) >>></p> <p>COLLECTOR SIDE TUBE OUTLET DIA. (FT) >>></p> <p>STORAGE SIDE TUBE (INCH) INLET DIA. (FT) >>></p> <p>COLLECTOR SIDE TUBE VELOCITY (FT/SEC) >>></p> <p>STORAGE SIDE TUBE VELOCITY (FT/SEC) >>></p> <p>HEAT EXCHANGER LENGTH (FT) >>></p> <p>HEAT EXCHANGER EFFICIENCY (FT/SEC) >>></p> <p>HEX AREA/AR DIA/LEN DIFFERENTIAL (FT) >>></p> <p>COLLECTOR SIDE TUBE DIA. DIFFERENTIAL (FT) >>></p> <p>COLLECTOR SIDE TUBE DIA. DIFFERENTIAL (FT) >>></p> <p>STORAGE SIDE TUBE DIA. DIFFERENTIAL (FT) >>></p> <p>CAPACITY FACTOR (KWH/FT**2) >>></p> <p>FLOW PARAMETERS (GPM/FT**2) >>></p> <p>FLOW PARAMETERS (GPM/FT**2) >>></p> </div> <div> <p>>>> HEIGHTED AVERAGE</p> <hr/> <p>COLLECTOR SIDE CAPACITY (BTU/HP F) >>></p> <p>STORAGE SIDE CAPACITY (BTU/HP F) >>></p> <p>COLLECTOR SIDE CONVECTION COEFF. >>></p> <p>STORAGE SIDE CONVECTION COEFF. >>></p> <p>COLLECTOR SIDE FLOW RATE (GPM) >>></p> <p>STORAGE SIDE FLOW RATE (GPM) >>></p> <p>NORMALIZED STORAGE FLOW (GPM/AREA) >>></p> <p>NORMALIZED STORAGE FLOW (GPM/AREA) >>></p> <p>HEAT EXCHANGER EFFICIENCY >>></p> <p>SOLAR ENERGY DELIVERED (BTU/YEAR) >>></p> <p>ACTUAL ENERGY DELIVERED (BTU/YEAR) >>></p> <p>ANNUAL AVERAGE SOLAR LOAD FACTOR >>></p> <p>PERCENTAGE OF PV OF SOLAR IRRADIANCE >>></p> <p>HEX EFFICIENCY (BTU/HP F FT**2) >>></p> <p>TOTAL INSTALLED CAPACITY (BTU/HP F) >>></p> <p>COLLECTOR FLOW PARAMETERS (GPM/FT**2) >>></p> <p>COLLECTOR FLOW PARAMETERS (GPM/FT**2) >>></p> </div> </div>																



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LOCATION	OAKLAND	CALIF.	COLLECTOR	FEDERAL PRISON I. D.	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....			COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....		37.73	SLOPE:		SYSTEM LIFE (YEARS)...	20.00
MEAN TEMPERATURE.....		56.59	PARAMETER, FRUL.....	0.8830	DISCOUNT RATE.....	C.0960
INSL (BTU/DAY FT*2)		1535.21	INTERCEPT:		INFLATION RATE.....	C.1100
LEAD FACTOR, HLT.....		3145.90	PARAMETER, FRTA.....	0.6270		
LEAD FACTOR, HLT.....		66.90	BASE COST, FRT**2.....	9.40		

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	EFFICIENCY	COST	HEATING VALUE	OIL
1	0.70	0.50 (\$/GAL)	142000.0 (BTU/GAL)	COLLECTOR FLUID DENSITY (LB/FT*3).....
1	0.70	0.50 (\$/KWH)	3413.0 (BTU/KWH)	COLLECTOR FLUID SPECIFIC HEAT (BTU/LP*F).....
2	0.79	0.65 (\$/KWH)	100000.0 (BTU/KWH)	COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F).....
3	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	STORAGE FLUID MEAN TEMPERATURE (°F).....
				STORAGE FLUID MEAN TEMPERATURE (°C).....
				COLLECTOR FLUID MEAN TEMPERATURE (°F).....
				COLLECTOR FLUID MEAN TEMPERATURE (°C).....
				176.00
				60.81
				1.0000
				0.3870
				104.00
				62.00

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LOAD LOSS	COEFFICIENT (BTU/HR F T**2) ..	ESTIMATED OPTIMUM STORAGE (LBS/AREA)	15.300
LOAD SURFACE HEAT TRANSFER AREA (F T**2) ..	5000.00	ESTIMATED GROUTING PUMPING POWER (KWH/AREA)	10.200
LOAD CONDUCTANCE (BTU/DEG F T**2) ..	20399.99	ESTIMATED CURRECT LIN FOR TAU ALPHA PRD.	1.0000
DOME STRUCT WATER (DHW) DESIGN TEMP.	100.00	ESTIMATED INSSTALL/LABCF COST (\$/AREA)	10.000
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	20.00	ESTIMATED HEX COST (\$/F T**2)	5.000
ESTIMATED UTILIZERS (PER)	1.00	ESTIMATED STORAGE TANK COST (\$/LH STORED)	0.000

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY RASH		HEATING VALUE		OIL	
INDEX	TYPE EFFICIENCY	COST	HEATING VALUE	COST	HEATING VALUE
1	OIL	0.50 (\$/GAL)	142000.0 (BTU/GAL)	0.50 (\$/GAL)	142000.0 (BTU/GAL)
2	ELE	0.99	3413.0 (BTU/KWH)	0.05 (\$/KWH)	3413.0 (BTU/KWH)
3	GAS	0.70	100000.0 (BTU/TH1)	0.40 (\$/TH1)	100000.0 (BTU/TH1)

HEAT LOAD CHARACTERISTICS	
LOAD LOSS	COEFFICIENT (BTU/HR. F. FT**2) .. 0.17
LOAD SURFACE	HEAT TRANSFER AREA (FT**2) .. 5000.00
LOAD CONDUCTANCE	(BTU/DEG F. SQ. FT.) .. 20399.99
DOMESTIC HOT WATER (DHW)	DESIGN TEMP. 100.00
ESTIMATED DAILY DHW USAGE	(GAL/PER) 20.00
ESTIMATED UTILIZERS (PER)	..... 0.00
ESTIMATED STORAGE FC LOAD EFFECTIVENESS	..... 1.00

COLLECTOR FLUID MEAN TEMPERATURE	
COLLECTOR FLUID DENSITY (LB/FT**3) ..	176.00
COLLECTOR FLUID SPECIFIC HEAT (BTU/LP*F) ..	60.81
COLLECTOR FLUID CONDUCTIVITY (BTU/LP*F) ..	1.0000
COLLECTOR FLUID CONDUCTIVITY (RTU/HQ*FT*F) ..	1.0000
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY (LB/FT**3) ..	62.00
STORAGE FLUID SPECIFIC HEAT (BTU/LP*F) ..	1.0000
STORAGE FLUID CONDUCTIVITY (BTU/LP*F) ..	0.3640
COLLECTOR SIDE FOULING FACTOR (HR F/RTU) ..	0.0010
COLLECTOR SIDE FOULING FACTOR (HR F/RTU) ..	0.0010
HEX TUBE CONDUCTIVITY (BTU/HR FT F) ..	220.00
ESTIMATED OPTIMUM STORAGE (LB/AREA)	15.30
ESTIMATED OPTIMUM REFLECTANCE	0.20
ESTIMATED PUMPING POWER (KWH/AREA)	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PRFD. ..	0.93
ESTIMATED INSTALL/LABEL COST (\$/AREA) ..	10.00
ESTIMATED HEX COST (\$/F T*2) ..	5.00
ESTIMATED STORAGE TANK COST (\$/LB STORED) ..	0.08
MAINTENANCE (& INSTALLED COST/YR)	0.0010

COLLECTOR
CALIF
COLLECTOR FEDERAL PRISON I.D.
STUDY APPROACH
ANALYSIS IS

[illegible]



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>> DATA MATCH TO INPUT ID NO. 9232
 QMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSCLAT ION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE DEG F	HEATING LOAD BTU/MONTH	DHW LOAD BTU/MONTH	EXTRA- TERRESTRIAL INSCLAT ION BTU/DAY FT**2	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
JAN	707.9	518.2	46.2	0.1057E 07	0.2637E 07	1407.4	1.684	0.296
FEB	1017.4	376.5	51.7	0.7681E 07	0.2382E 07	1838.5	1.473	0.455
MAR	1456.3	370.3	53.1	0.7554E 07	0.2637E 07	2458.1	1.225	0.587
APR	1922.1	291.5	55.3	0.5947E 07	0.2552E 07	3055.3	1.019	0.712
MAY	2211.3	222.0	58.0	0.4223E 07	0.2637E 07	3553.7	0.890	0.812
JUN	2350.0	138.2	61.0	0.2815E 07	0.2552E 07	3750.2	0.838	0.925
JUL	2322.5	110.2	61.8	0.2248E 07	0.2637E 07	3660.4	0.861	0.981
AUG	2052.6	91.2	62.4	0.1363E 07	0.2637E 07	3287.3	0.963	1.000
SEP	1701.2	75.6	63.4	0.1542E 07	0.2552E 07	2698.9	1.149	1.000
OCT	1212.0	151.3	60.4	0.3037E 07	0.2637E 07	2027.5	1.402	0.810
NOV	822.2	307.4	54.6	0.6271E 07	0.2552E 07	1510.1	1.654	0.479
DEC	647.0	493.0	49.1	0.1006E 08	0.2627E 07	1275.6	1.778	0.293
TOTAL		3145.4			0.3105E 08			
>>>WEIGHTED AVERAGE 0.602								
OTHER PARAMETERS								
COLLECTOR AREA (FT**2)	>>>							
COLLECTOR TILT ANGLE (DEG)	>>>							
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>							
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>							
STORAGE SIDE TUBE (INCH)	>>>							
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>							
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>							
HEAT EXCHANGER LENGTH (FT)	>>>							
HEAT EXCHANGER DIAMETER (INCH)	>>>							
COLLECTOR SIDE TUBE DIA. DIFFERENTIAL (FT)	>>>							
COLLECTOR SIDE REYNOLDS NUMBER	>>>							
STORAGE SIDE REYNOLDS NUMBER	>>>							
CAPACITY RATIO (CMIN/CMAX)	>>>							
FLOW PARAMETER 22 (GPM/FT**2)	>>>							
FLOW PARAMETER 21 (GPM/FT**2)	>>>							
COLLECTOR TILT ANGLE (DEG)	>>>							
COLLECTOR SIDE TUBE DIA. (FT)	>>>							
COLLECTOR SIDE TUBE DIA. (FT)	>>>							
STORAGE SIDE TUBE DIA. (FT)	>>>							
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>							
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>							
HEAT EXCHANGER LENGTH (FT)	>>>							
HEAT EXCHANGER DIAMETER (INCH)	>>>							
COLLECTOR SIDE TUBE DIA. DIFFERENTIAL (FT)	>>>							
COLLECTOR SIDE REYNOLDS NUMBER	>>>							
STORAGE SIDE REYNOLDS NUMBER	>>>							
CAPACITY RATIO (CMIN/CMAX)	>>>							
FLOW PARAMETER 22 (GPM/FT**2)	>>>							
FLOW PARAMETER 21 (GPM/FT**2)	>>>							



S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 10111
IMDD-1 LWK AUGUST 1979

LOCATION	ERYCLE	CANYON	UT	COLLECTOR SOLARMETICS	STUDY APPROACH	ANALYSIS
COLLECTOR TEST RESULTS,						
LATITUDE INLLX.....	10					
LATITUDE, DEGREES.....	37.70					
MEAN TEMPERATURE.....	40.27					
INSOL (BTU/DAY FT**2)	1739.77			1.0380		20.00
LOAD FACTOR, HDD.....	9044.25			0.6910		0.1150
MEAN GROUND TLMP.....	55.00			12.98		0.1050
SYSTEM LIFE (YEARS)...						
DISCOUNT RATE						
INFLATION RATE						

ENERGY COMPARATIVE ESTIMATES

TYPE	INDEX	ENERGY EFFICIENCY	COST	HEATING VALUE	JIL
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	LLE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)...	0.25
LOAD SURFACE HEAT TRANSFER AREA (FT**2)...	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)...	30000.00
DOMESTIC HOT WATER (LHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED CH-1 USERS (PER)	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS...	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.....	176.00
COLLECTOR FLUID DENSITY (LR/FT**3).....	60.81
COLLECTOR FLUID SPECIFIC HEAT (BTU/LP*F)...	1.0000
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F)...	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY (LB/FT**3).....	62.09
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY (BTU/HR FT F)...	0.3640
COLLECTOR SIDE FOULING FACTOR (HR F/RTU)...	0.0010
STORAGE SIDE FOULING FACTOR (HR F/RTU)...	0.0010
HEX TUBE CONDUCTIVITY (BTU/HR FT F).....	220.00
ESTIMATED OPTIMUM STORAGE (LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE	0.20
ESTIMATED PUMPING POWER (KWH/AREAC).....	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PEED...	0.93
ESTIMATED INSTALL/LABOR CCST (\$/AREAC)...	10.00
ESTIMATED HEX COST (\$/FT**2)	5.00
ESTIMATED STORAGE TANK COST (\$/LB STORED)...	0.08
MAINTENANCE (% INSTALLED CCST/YR)	0.01



SCALAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
RESULTS OF ANALYSIS FOR BRYCE CARYON UT

>>>>>DATA '44TCF T7 INPUT ID NO. 10111
'JMUJ-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	HEATING LOAD	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2	EXTRA-TERRESTRIAL INSCLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY	FT**2	DEG F	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2			
JAN	514.0	1412.0	19.5			0.4236E	08	0.2637E	07	1408.9	1.879	0.246
FEB	1236.0	1186.0	23.2			0.3558E	08	0.2382E	07	1839.5	1.578	0.308
MAR	1685.0	1114.0	29.1			0.3342E	08	0.2637E	07	2455.2	1.256	0.389
APR	2133.0	821.4	37.6			0.2464E	08	0.2552E	07	3095.9	1.001	0.488
MAY	2454.0	542.0	47.5			0.1626E	08	0.2637E	07	3553.5	0.850	0.649
JUN	2655.0	249.0	56.9			0.1470E	07	0.2552E	07	3750.1	0.788	0.925
JUL	2424.0	16.9	63.2			0.2307E	07	0.2637E	07	3660.5	0.819	1.000
AUG	2157.0	144.4	60.6			0.4332E	07	0.2637E	07	3287.7	0.934	1.000
SEP	1520.0	270.0	52.7			0.1110E	08	0.2552E	07	2699.9	1.159	0.825
OCT	1465.0	710.0	42.1			0.2130E	08	0.2637E	07	2038.8	1.491	0.569
NOV	1016.0	1060.0	29.6			0.3180E	08	0.2552E	07	1511.6	1.816	0.337
DEC	818.2	1358.6	21.2			0.4076E	08	0.2637E	07	1281.1	1.987	0.238
TOTAL		9044.3				0.2713E	09	0.3105E	08		AVERAGE	0.431
DESIGN VARIABLES/CONSTRAINTS												
COLLECTOR AREA	(FT**2)					487.11	COLLECTOR SIDE CAPACITY	(BTU/HR	F)			0.490E 04
COLLECTOR TILT ANGLE	(DEG)					44.63	STORAGE SIDE CAPACITY	(BTU/HR	F)			0.877E 05
COLLECTOR SIDE TUBE INNER DIA.	(FT)					0.0956	COLLECTOR SIDE CONVECTION COEFF.					1028.8706
COLLECTOR SIDE TUBE OUTER DIA.	(FT)					0.1006	STORAGE SIDE CONVECTION COEFF.					4185.7383
STORAGE SIDE TUBE(OUT) INNER DIA.	(FT)					0.1765	COLLECTOR SIDE FLOW RATE	(GPM)				10.0398
COLLECTOR SIDE FLUID VELOCITY	(FT/SEC)					3.1173	STORAGE SIDE FLOW RATE	(GPM)				176.0206
STORAGE SIDE FLUID VELOCITY	(FT/SEC)					23.7328	NORMALIZED COLLECTOR FLOW	(GPM/AREA)				0.0206
HEAT EXCHANGER LENGTH	(FT)					125.79	NORMALIZED STORAGE FLOW	(GPM/AREA)				0.3614
HEAT EXCHANGER EFFECTIVENESS							HEAT EXCHANGER EFFECTIVENESS					0.9018
HEX ANNUAL DIAMETER DIFFERENCE	(FT)					0.0059	SOLAR ENERGY DELIVERED	(BTU/YEAR)				0.130E 09
COLLECTOR SIDE TUBE DIA. DIFFERENCE	(FT)					0.0050	TOTAL ENERGY DEMAND	(BTU/YEAR)				0.302E 09
COLLECTOR SIDE REYNOLDS NUMBER						0.160E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION					0.4311
STORAGE SIDE REYNOLDS NUMBER						0.259E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT					0.650E 04
CAPACITY RATIO (CMPI/CHAX)						0.0559	HEX COEFFICIENT (BTU/HR F FT**2)					311.52
FLOW PARAMETER Z2 (GCP/FRUL)						9.6848	TOTAL INSTALLATION COST (\$)					14605.078
FLOW PARAMETER Z1 (GCP/FRPUL)						7.18	COLLECTOR FLOW FACTOR (FPP)					0.5474



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SCALAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIMIS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 10112
IMOC-1 LWK AUGUST 1979

COLLOCATION	ERYCE CANYON JT	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES				
CLCATION INDEX.....	10	COLLECTOR TEST RESULTS,		
LATITUDE DEGREES.....	37.70	SLOPE:		
MEAN TEMPERATURE.....	40.27	PARAMETER, FRUL....	1.0380	
INSOLATION PER DAY FT*2)	1739.77	INTERCEPT:		
LOAD FACTOR, MOD.....	9044.29	PARAMETER, FRTA....	0.6910	
AVERAGE GROUND TEMP.....	55.00	RASE COST, \$/FT*2....	12.98	
				SYSTEM LIFE(YEARS).. DISCOUNT RATE..... INFLATION RATE.....
				20.00 0.1150 0.1050

SELECTED PARAMETERS

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY BASE TYPE	EFFICIENCY	COST	HEATING VALUE	DIL
1	OIL	0.70	0.50 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELE	0.99	1.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	

HEAT LOAD CHARACTERISTICS	
LOAD INDEX	CHARACTERISTICS
1	COLLECTOR FLUID MEAN TEMPERATURE
2	COLLECTOR FLUID DENSITY (LB/FT**3)
3	COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)
4	COLLECTOR FLUID CONDUCTIVITY (BTU/HR FT F)
5	STORAGE FLUID MEAN TEMPERATURE
6	STORAGE FLUID DENSITY (LB/FT**3)
7	STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)
8	STORAGE FLUID CONDUCTIVITY (BTU/HR FT F)
9	COLLECTOR SIDE FOULING FACTOR (HR F/RTU)
10	STORAGE SIDE FOULING FACTOR (HR F/RTU)
11	HEX TUBE CONDUCTIVITY (BTU/HR FT F)
12	ESTIMATED OPTIMUM STORAGE (LB/AREAC)
13	ESTIMATED GROUND REFLECTANCE
14	ESTIMATED PUMPING POWER (KWH/AREAC)
15	ESTIMATED CORRECTION FOR TAU ALPHA PRFD.
16	ESTIMATED INSTALL/LABEL COST (\$/AREAC)
17	ESTIMATED HEX COST (\$/FT**2)
18	ESTIMATED STORAGE TANK COST (\$/LB STORED)
19	MAINTENANCE (% INSTALLED COST/YR)

LOAD INDEX	CHARACTERISTICS
1	LCSS COEFFICIENT (BTU/HR FT**2)
2	LOAD SURFACE HEAT TRANSFER AREA (FT**2)
3	LCAC CONDUCTANCE (BTU/DEC DAY)
4	DOMESTIC HOT WATER (GPH) DESIGN TEMP.
5	ESTIMATED DAILY DHW USAGE (GAL/PER)
6	ESTIMATED DHW USERS (PER)
7	ESTIMATED STORAGE TO LOAD EFFECTIVENESS

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEC F DAY) ..	20399.99
DOMESTIC HOT WATER (GPH) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW USER (PER) ..	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS ..	1.00

148



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
RESULTS OF ANALYSIS FOR Bryce Canyon UT

RESULTS OF ANALYSIS FOR BRYCE CANYON LT

>>>>>DATA MATCH TO INPUT ID NC. 10112
147D-1 LWK AUGUST 1975

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS		>>>WEIGHTED AVERAGE	
COLLECTOR AREA (FT*2)	351.69	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.351F	0.4	0.442
COLLECTOR TILT ANGLE (DEG)	4.21	STORAGE SIDE CAPACITY (BTU/HR F)	0.587E	0.5	
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0817	COLLECTOR SIDE CONVECTION COEFF.	1044.5513	0.5	
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0873	STORAGE SIDE CONVECTION COEFFICIENT	3565.6694	0.5	
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)	0.1523	COLLECTOR SIDE FLOW RATE (GPM)	7.1982	0.5	
COLLECTOR SIDE FLOW VELOCITY (FT/SEC)	3.0556	STORAGE SIDE FLOW RATE (GPM)	117.7632	0.5	
STORAGE SIDE FLOW VELOCITY (FT/SEC)	21.4609	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0205	0.5	
HEAT EXCHANGER LENGTH (FT)	95.55	NORMALIZED STORAGE FLOW (GPM/AREAC)	0.3349	0.5	
HEAT EXCHANGER EFFECTIVENESS		HEAT EXCHANGER EFFECTIVENESS	0.8780	0.5	
HEX ANNUAL DIAMETER DIFFERENCE (FT)	0.0050	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.952E	0.8	
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	0.0056	TOTAL ENERGY DEMAND (BTU/YEAR)	0.216F	0.9	
COLLECTOR SIDE REYNOLDS NUMBER	0.637E	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4416	0.5	
STORAGE SIDE REYNOLDS NUMBER	0.197E	OBJECTIVE: NPV OF SOLAR INVESTMENT	0.517F	0.4	
CAPACITY RATIO (CMH/CMAX)	0.0599	HEX COEFFICIENT (BTU/HR F FT*2)	311.95	0.5	
FLUX PARAMETER Z2(GCP/FRUL)	9.6175	TOTAL INSTALLATION COST (\$)	10528.49	0.5	
FLOW PARAMETER Z1(GCP/FRPUL)	9.11	COLLECTOR FLOW FACTOR(FPP)	0.9471	0.5	





S O L O A D - 1
SOLAP ENERGY OPTIMIZATION ANALYSIS OR DESIGN
RESULTS OF ANALYSIS FOR BRUCE CANYON UT

>>>>DATA MATCH TO INPUT ID NO. 10113
JANEC-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSULATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE		HEATING LOAD		CHW LOAD		EXTRA-TERRRESTRIAL INSULATION		COLLECTOR TILT FACTOR		SOLAR ENERGY FRACTION	
	BTU/EAY	FT*2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY	FT*2					
JAN	914.0		1412.0	19.5	0.1525E 08	0.2637E 07	0.2637E 07	1408.9	1.862	0.284						
FEB	1236.0		1186.0	23.2	0.1281E 08	0.2382E 07	0.2382E 07	1835.5	1.570	0.354						
MAR	1685.0		1114.0	29.1	0.1203E 08	0.2637E 07	0.2637E 07	2459.2	1.257	0.442						
APR	2133.0		821.4	37.6	0.8871E 07	0.2552E 07	0.2552E 07	3095.9	1.010	0.540						
MAY	2454.0		542.0	47.5	0.5854E 07	0.2637E 07	0.2637E 07	3552.5	0.863	0.682						
JUN	2655.0		249.0	56.5	0.2689E 07	0.2552E 07	0.2552E 07	3750.1	0.803	0.898						
JUL	2424.0		76.9	63.2	0.8305E 06	0.2637E 07	0.2637E 07	3620.5	0.823	1.000						
AUG	2157.0		144.4	60.6	0.1560E 07	0.2637E 07	0.2637E 07	3287.7	0.944	0.968						
SEP	1920.0		370.4	52.7	0.3992E 07	0.2552E 07	0.2552E 07	2255.5	1.163	0.825						
OCT	1465.0		710.0	42.1	0.7668E 07	0.2637E 07	0.2637E 07	2038.8	1.486	0.608						
NOV	1016.0		1060.0	29.6	0.1145E 08	0.2552E 07	0.2552E 07	1511.6	1.800	0.379						
DEC	818.2		1353.6	21.2	0.1467E 08	0.2637E 07	0.2637E 07	1281.1	1.966	0.273						
TOTAL			9044.5		0.9708E 08	0.3105E 08	0.3105E 08									

>>>WEIGHTED AVERAGE
OTHER PARAMETERS

COLLECTOR AREA (FT**2)	TILT ANGLE (DEG)	TUBE INNER DIA. (FT)	TUBE OUTER DIA. (FT)	STORAGE SIDE TUBE(EXT) INNER DIA. (FT)	STORAGE SIDE FLUID VELOCITY (FT/SEC)	STORAGE SIDE FLUID VELOCITY (FT/SEC)	HEAT EXCHANGER LENGTH (FT)	HEAT EXCHANGER PRESSURE DROPS (PSI)	HEX ANNUAL DIAPHRAGM DIFFERENCE (FT)	COLLECTOR SIDE TUBE RYNDUS NUMBER	STORAGE SIDE RYNDUS NUMBER	CAPACITY RATIO (GAL/CHAL)	FLOW PARAMETER Z (GCP/CHAL)	FLOW PARAMETER Z (GCP/FRPUL)
>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
230.38	42.95	0.0638	0.0706	0.1372	3.2870	20.1926	92.29	0.0666	0.0068	0.535E-05	0.190E-06	0.0470	9.6287	9.12
COLLECTOR SIDE CAPACITY (BTU/HR F)	42.95	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.0638	COLLECTOR SIDE CONVECTION COEFFICIENT	0.0706	COLLECTOR SIDE FLOW RATE (GPM)	0.1372	STORAGE SIDE FLOW RATE (GPM)	3.2870	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	20.1926	HEAT EXCHANGER EFFECTIVENESS	92.29	SOLAR ENERGY DEMAND (BTU/YEAR)
HEAT EXCHANGER EFFECTIVENESS	0.0666	TOTAL ENERGY DELIVERED (BTU/YEAR)	0.0068	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.535E-05	PROJECTIVE: TYPV OF SOLAR INVESTMENT	0.190E-06	HEX COEFFICIENT (BTU/HR F FT**2)	0.0470	TOTAL INSTALLATION COST (\$)	9.6287	COLLECTOR FLOW FACTOR (FPP)	9.12	0.947



SCIENCE IN ENERGY OPTIMIZATION ANALYSIS OF DESIGN

DESIGN DATA CAPTURES/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 10213
IMOD-1 LWR AUGUST 1979

MEAN TEMPERATURE.....	40.27	PARAMETER, FROD.....	1.0360	SYSTEM LIFE(YEARS).. DISCOUNT RATE	20.00 C.0900
INSL(BTL/DAY FT#2)	1739.77	INTERCEPT:			
LOAD FACTOR, HOD.....	SC44.29	PARAMETER, FRIA.....	0.6910	INFLATION RATE.....	0.1100
MEAN GROUND TEMP.....	55.00	BASE COST,\$/FT#2....	12.98		

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.....	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).....	60.81
COLLECTOR FLUID SPECIFIC HEAT(PTU/LR*F).....	1.0000
COLLECTOR FLOID CONDUCTIVITY(RTC/LR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE.....	104.00
STORAGE FLUID DENSITY(LR/FT**3).....	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LR*F).....	1.0000
STORAGE FLUID CONDUCTIVITY(PTU/LR FT F).....	0.3640
COLLECTOR SIDE FOULING FACTOR(LR F/ETH)	0.0010
STORAGE SIDE FOULING FACTOR(LR F/ETH)	0.0010
HEX TUBE CONDUCTIVITY(BTU/LR FT F).....	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREA).....	15.30
ESTIMATED GROUND REFLECTANCE.....	0.20
ESTIMATED PUMPING POWER(KWH/APEAC).....	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PRED.	0.93
ESTIMATED INSTALL/LABOR COST (\$/AREA).....	10.00
ESTIMATED HEX COST (\$/FT**2).....	5.00
ESTIMATED STORAGE TANK COST (\$/LR STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).....	0.00



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SCALAR ENERGY OPTIMIZATION ANALYSIS TR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

TO INPUT ID NO. 10213
OMDC-1 LHK AUGUST 1979

>>WEIGHTED AVERAGE

DES IGT VARIABLES INSTRUMENTS

COLLECTOR AREA	(FT**2)	ANGLE (DEG)	INNER DIA. (FT)	OUTER DIA. (FT)	INNER DIA. (FT)	COLLECTOR SIDE TUBE (HEX) FLUID VELOCITY (FT/SEC)	COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	HEAT EXCHANGER LENGTH (FT)	CONSTRAINTS	HEX ANNUAL DIAMETER DIFFERENCE (FT)	COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	COLLECTOR SIDE FEYHOL'S NUMBER	COLLECTOR SIDE FEYHOL'S NUMBER	CAPACITY RATIO (CAP/FEYHOL)	FLOW PARAMETER Z1 (GCF/ERPHL)	FLOW PARAMETER Z2 (GCF/ERPHL)	FLOW PARAMETER Z3 (GCF/ERPHL)
35.55	>>>								COLLECTOR SIDE CAPACITY (BTU/HR)	0.3835	0.4						
48.50	>>>								STORAGE SIDE CAPACITY (BTU/HR)	0.4666	0.5						
0.0719	>>>								COLLECTOR SIDE CONVECTION COEFF.	1411.7432							
0.0769									STORAGE SIDE CONVECTION COEFFICIENT	3531.1611							
0.1416									COLLECTOR SIDE FLOW RATE (GPM)	7.8504							
4.3116									STORAGE SIDE FLOW RATE (GPM)	93.6463							
18.7355									NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0221							
90.70									NORMALIZED STORAGE FLOW (GPM/AREAC)	0.2634							
									HEAT EXCHANGER EFFECTIVENESS	0.8204							
0.0647									SOLAR ENERGY DELIVERED (BTU/YEAR)	0.8145	0.8						
0.0050									TOTAL ENERGY DEMAND (HTU/YEAR)	0.1295	0.9						
0.7905									ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6322							
0.1725									OBJECTIVE: HPV OF SOLAR INVESTMENT	>>>							
0.0321									HEX COEFFICIENT (BTU/HR F FT**2)	0.8585	0.4						
10.3750									TOTAL INSTALLATION COST (\$)	335.52							
9.87									COLLECTOR FLOW FACTOR (FPP)	8708.16							



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      S O L U T I O N - 1
      **
      ** OPTIMIZATION ANALYSIS TO CUSTOMER
      **
      ** DATA CPDIOIS/INPUTS SUMMARY
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      *** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** **
      >>>>DATA MATCH TO OUTPUT ID NO. 10221
      INCD-1 LAR AUGUST 1979

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LINEAR ALGEBRA

LOCATION INDEX.....	10	
LATITUDE, DEGREES.....	37.70	
LONGITUDE, DEGREES.....	40.27	
MEAN TEMPERATURE.....	49.77	
INSCAL (BTU/DAY FT**2)	1739.77	
CLAD THICKNESS.....	5044.25	
CLAD MATERIAL.....	55.00	
CLAD CONDUCTIVITY.....	66.00	
COLLECTOR TEST RESULTS,		
SLOPE.....		1.0350
INTERCEPT.....		0.6380
PARAMETER, FRU.....		6.25
PARAMETER, FRA.....		6.25
PARAMETER, FET**2.....		
ECONOMIC ESTIMATES		
SYSTEM LIFE (YEARS).....		
DISCOUNT RATE.....		
INFLATION RATE.....		

ENVIRONMENTAL POLICY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	PASSE EFFICIENCY	COST	HEATING VALUE	OIL
1	CH	0.70	0.50 (\$/Btu)	142000.0 (Btu/Gal)	
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (Btu/KWH)	
3	GAS	0.70	0.40 (\$/MM)	100000.0 (Btu/MM)	

HEAT LOSS CHARACTERISTICS	
LOAD LOSS COEFFICIENT (BTU/HR. FT**2) ..	0.25
UNAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
UNAD CONDUCTANCE (BTU/DEG. FT**2) ..	30000.00
TEMPERATURE DIFFERENCE (DEG. F) ..	100.00
ESTIMATED DAILY OIL USAGE (GAL/DAY) ..	20.00
ESTIMATED OIL FLOW (GPM) ..	6.00
ESTIMATED STORAGE TANK CAPACITY (GAL) ..	1.00



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RESULTS OF ANALYSIS FOR BRVCT CANYON OF

FO INPUT ID NO. 10221
M40D-1 LWK AUGUST 1975

DOI: 10.1002/vof.10001 / CREST KAJI MATS.

COLLECTOR AREA (FT**2)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	1106.59	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.109F 04
COLLECTOR TILT ANGLE (DEG)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	49.35	STORAGE SIDE CAPACITY (BTU/HR F)	0.109F 04
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.1318	COLLECTOR SIDE CONVECTION COEFF.	1094.7612
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.1375	STORAGE SIDE CONVECTION COEFFICIENT	4364.8516
COLLECTOR SIDE TUBE(OUT X) INNER DIA. (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.2311	COLLECTOR SIDE FLOW RATE (GPM)	22.2473
COLLECTOR SIDE TUBE FLUT/FLUT (FT/SEC)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	3.6510	STORAGE SIDE FLOW RATE (GPM)	319.6243
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	26.3040	HEAT EXCHANGER COLLECTOR FLOW (GPM/AREA)	0.0203
HEAT EXCHANGER LENGTH (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	145.52	NORMALIZED STORAGE FLOW (CPW/AREA)	0.2683
HEAT EXCHANGER CAPTAINIES	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.0935	HEAT EXCHANGE EFFECTIVENESS	0.8224
HEX ANNUAL DIAMETER DIFFERENCE (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.0957	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.153F 05
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.123E 06	TOTAL ENERGY DEMAND (BTU/YEAR)	0.302F 05
COLLECTOR SIDE FLOWING NUMBER	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.347E 06	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2555
STORAGE SIDE FLOWING NUMBER	>>>	>>>	>>>	>>>	>>>	>>>	>>>	0.0685	PROJECTIVE: MPV OF SOLAR INVESTMENT	>>>
CAPACITY COST (COST/FT**2)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	9.332	HEX COEFFICIENT (BTU/HR F FT**2)	0.219F 05
FLOW PARAMETER Z2 (C/P/FT**2)	>>>	>>>	>>>	>>>	>>>	>>>	>>>	3.97	TOTAL INSTALLATION COST (\$)	317.39
FLOW PARAMETER Z1 (C/P/FT**2)	>>>	>>>	>>>	>>>	>>>	>>>	>>>		COLLECTOR FLOW FACTOR(FPP)	1.057556
	>>>	>>>	>>>	>>>	>>>	>>>	>>>			0.5463



CLAUDE L.

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S C L U A U - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS AND DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY
>>>>>DATA MATCH TO OUTPUT ID NO. 10222
IMCD-1 LAK AUGUST 1979

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LOCATION	BRYCE CANYON UT	COLLECTOR AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCAT ION INDEX.....	10	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....	37.70	SLOPE:		
MEAN TEMPERATURE.....	40.27	PARAMETER, FRUL....		
INSL (BTU/ DAY FT*2)	1759.77	INTERCEPT:		
LOAD FACTOR, MOD.....	9044.29	PARAMETER, FKTA....	SYSTEM LIFE(YEAPS) ..	20.00
LEAD GROUND TEMP.....	55.00	BASE COST, \$/FT*2...	DISCOUNT RATE.....	C.09CC
			INFLATION RATE.....	O.1100

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90 (\$/GAL)	14200.0 (BTU/GAL)	
2	ELE	0.95	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	

HEAT LOAD CHARACTERISTICS.

LOAD LOSS COEFFICIENT (BTU/H ² F FT**2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	20399.99
DOMESTIC HOT WATER (DEG) DESIGN TEMP. ..	140.00
ESTIMATED DAILY DHW USE AG (GAL/PER) ..	20.00
ESTIMATED DHW USE RS (GAL) ..	6.00
ESTIMATED STORAGE TC LEAKS EFFECTIVENESS ..	1.00

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).....
COLLECTOR SIDE FOULING FACTOR(FR F/RTU).....
COLLECTOR SIDE FOULING FACTOR(HE F/BTU).....
HEX CUBE CONDUCTIVITY(BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE(LB/AREA).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AF*EAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PFED.....
ESTIMATED INSTALL/LABOR COST ($/FT**2).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LB STORED).....
ESTIMATED MAINTENANCE & INSTALLD COST/YR.....

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	176.00
	60.81
	1.0000
	0.3870
	104.00
	62.05
	1.0000
	0.3640
	0.0010
	0.0010
	220.00
	15.30
	0.20
	1.0000
	0.93
	10.00
	5.00
	0.98
	0.0010



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 RESULTS OF ANALYSIS FOR BRYCE CANYON UT
 JMCU-1 LWK AUGUST 1979

MONTH	HORIZINTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	3 FU/MONTH	EXTRA-TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	3 FU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.2380E 08	0.2637E 07	1408.9	1.925	0.455	
FEB	1236.0	1186.0	23.2	0.2419E 08	0.2382E 07	1839.9	1.597	0.552	
MAR	1585.0	1114.0	29.1	0.2273E 08	0.2637E 07	2455.2	1.246	0.658	
APR	2133.0	821.4	37.6	0.1676E 08	0.2552E 07	3095.9	0.970	0.760	
MAY	2454.0	542.0	47.5	0.1106E 08	0.2637E 07	3553.9	0.808	0.892	
JUN	2655.0	249.0	56.9	0.5080E 07	0.2552E 07	3750.1	0.742	1.000	
JUL	2424.0	76.9	63.2	0.1509E 07	0.2637E 07	3660.5	0.776	1.000	
AUG	2157.0	144.4	60.6	0.2940E 07	0.2637E 07	3287.7	0.858	1.000	
SEP	1920.0	370.0	52.7	0.7545E 07	0.2552E 07	2695.9	1.140	0.869	
OCT	1405.0	110.0	42.1	0.1448E 08	0.2637E 07	2038.8	1.501	0.597	
NOV	1016.0	1060.0	29.6	0.2162E 08	0.2552E 07	1511.6	1.825	0.445	
DEC	1358.0	1358.0	21.2	0.2772E 08	0.2637E 07	1281.1	2.042		
TOTAL	818.2	9044.3		0.1845E 09	0.3105E 08			0.663	

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>
COLLECTOR TILT ANGLE (DEG)	>>>
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>
STORAGE SIDE TUBE(HX) INNER DIA. (FT)	>>>
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>
HEAT EXCHANGER LENGTH (FT)	>>>
COLLECTOR DIAMETER DIFFERENCE (FT)	>>>
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	>>>
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	>>>
STORAGE SIDE TUBE DIA. DIFFERENCE(FT)	>>>
CAPACITY RATIO (CMIN/CMAX)	>>>
FLOW PARAMETER 22(C/P/PAUL)	>>>
FLOW PARAMETER 21(C/P/PAUL)	>>>

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)	0.775E 04
STORAGE SIDE CAPACITY (BTU/HR F)	0.949E 05
COLLECTOR SIDE CONVECTION COEFFICIENT	1137.3516
STORAGE SIDE CONVECTION COEFFICIENT	4073.5055
COLLECTOR SIDE FLOW RATE (GPM)	15.8794
STORAGE SIDE FLOW RATE (GPM)	150.6151
NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC)	0.2432
HEAT EXCHANGER EFFECTIVENESS	0.8425
SOLAR ENERGY DELIVERED (BTU/YEAR)	0.143E 09
TOTAL ENERGY DEMAND (BTU/YEAR)	0.216E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6634
OBJECTIVE: NPV OF SOLAR INVESTMENT	0.161E 05
HFX COEFFICIENT (BTU/HR F FT**2)	323.83
TOTAL INSTALLATION COST (\$)	14164.61
COLLECTOR FLOW FACTOR(FPP)	0.9464



DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH P1 OUTPUT ID NO. 10223
IMOD-1 LWK AUGUST 1979

ANALYSIS

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BAS. EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90 (\$/GAL)	14200.0 (BTU/GAL)	
2	ELL	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	

HEAT LOAD CHARACTERISTICS

Variable	Value
LOAD	0.09
LCSS	5000.00
COEFFICIENT (BTU/HR-FT**2)	10759.99
SURFACE HEAT TRANSFER AREA (FT**2)	140.00
CONDUCTANCE (BTU/DEG F DAY)	20.00
DOMESTIC HOT WATER (GAL)	6.00
DESIGN TEMP	1.00
ESTIMATED DAILY HW USAGE (GAL/PER)	
ESTIMATED HW USER (PER)	
STORAGE TO LOAD EFFECTIVENESS	

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(HR*F/BTU).....
COLLECTOR SIDE FOULING FACTOR(HR*F/BTU).....
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE(LB/AR*AC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AFF*AC).....
ESTIMATED CORRECTION FOR TAU ALPHA PRCD.....
ESTIMATED INSTALL/LABCR COST ($/APT*AC).....
ESTIMATED HEX COST (LB/FT**2).....
ESTIMATED STORAGE TANK COST($/LB*STORED).....
MAINTENANCE (& INSTALLED COST/YR).....

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176.00
6C.81
1.0000
0.3870
1104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
C.93
10.00
15.00
0.08
0.0010

S U L T A D - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
RESULTS OF ANALYSIS FOR BRYCE CANYON UT
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	DHW LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEC DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.1525E 08	0.2637E 07	0.2637E 07	1408.9	1.917	0.468
FEB	1236.0	1186.0	23.2	0.1281E 08	0.2382E 07	0.2382E 07	1839.9	1.554	0.562
MAR	1685.0	1114.0	29.1	0.1203E 08	0.2637E 07	0.2637E 07	2459.2	1.248	0.666
APR	2133.0	821.4	37.6	0.8871E 07	0.2552E 07	0.2552E 07	3055.9	0.976	0.762
MAY	2454.0	542.0	47.5	0.5854E 07	0.2637E 07	0.2637E 07	3553.9	0.816	0.880
JUN	2655.0	245.0	56.5	0.2689E 07	0.2552E 07	0.2552E 07	3750.1	0.751	1.000
JUL	2424.0	76.9	63.2	0.3305E 06	0.2637E 07	0.2637E 07	3660.5	0.784	1.000
AUG	2157.0	144.4	60.6	0.1500E 07	0.2637E 07	0.2637E 07	3287.7	0.905	1.000
SEP	1920.0	370.0	52.7	0.3996E 07	0.2552E 07	0.2552E 07	2654.5	1.144	1.000
OCT	1465.0	710.0	42.1	0.7668E 07	0.2637E 07	0.2637E 07	2038.8	1.500	0.859
NOV	1016.0	1060.0	29.6	0.1145E 08	0.2552E 07	0.2552E 07	1511.6	1.848	0.601
DEC	818.2	1353.6	21.2	0.1407E 08	0.2637E 07	0.2637E 07	1281.1	2.033	0.453
TOTAL		5044.3		0.9768E 08	0.3105E 08			AVERAGE	0.679

>>>WEIGHTED AVERAGE
OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)									
COLLECTOR TILT ANGLE (DEG)									
COLLECTOR SIDE TUBE INNER DIA. (FT)									
COLLECTOR SIDE TUBE OUTER DIA. (FT)									
STORAGE SIDE TUBE (INCH)									
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)									
STORAGE SIDE FLUID VELOCITY (FT/SEC)									
HEAT EXCHANGER LENGTH (FT)									
HEAT EXCHANGER EFFECTIVENESS									
HEX ANNUAL DIAMETER DIFFERENCE (FT)									
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)									
STORAGE SIDE REYNOLDS NUMBER									
CAPACITY RATIO (CHM/CMAX)									
FLOW PARAMETER 22 (GCP/FRUL)									
FLOW PARAMETER 21 (GCP/FRUL)									
COLLECTOR SIDE CAPACITY (BTU/HR F)									
STORAGE SIDE CAPACITY (BTU/HR F)									
COLLECTOR SIDE CONVECTION COEFF.									
STORAGE SIDE CONVECTION COEFF.									
COLLECTOR SIDE FLOW RATE (GPM)									
STORAGE SIDE FLOW RATE (GPM)									
NORMALIZED COLLECTOR FLOW (GPM/AREAC)									
HEAT EXCHANGER EFFECTIVENESS									
SOLAR ENERGY DELIVERED (BTU/YEAR)									
TOTAL ENERGY DEMAND (BTU/YEAR)									
ANNUAL AVERAGE SOLAR LOAD FRACTION									
OBJECTIVE: NPV OF SOLAR INVESTMENT									
HEX COEFFICIENT (BTU/HR F FT**2)									
TOTAL INSTALLATION COST (\$)									
COLLECTOR FLOW FACTOR (FPP)									





SOLAR ENERGY OPTIMIZATION ANALYSIS JR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>DATA MARCH TC INPUT ID NO. 10231
MTC-1 LWA AUGUST 1979

MONTH	TOTAL INSULATION		HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXT. AMBIENT INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FACTOR
	RTU/LPY	FT**2							
JAN	514.0	1412.0	10.5	0.4236E 08	0.2637E 07	1408.5	1.922	0.423	
FEB	1236.0	1136.0	23.2	0.3558E 08	0.2382E 07	1839.9	1.590	0.522	
MAR	1685.0	1114.0	29.1	0.3342E 08	0.2637E 07	2455.2	1.247	0.628	
APR	2123.0	821.4	37.6	0.2464E 08	0.2552E 07	3055.9	0.974	0.740	
MAY	5454.0	542.0	47.5	0.1626E 08	0.2637E 07	3553.9	0.811	0.856	
JUN	2625.0	245.0	56.5	0.7470E 07	0.2552E 07	3750.1	0.746	1.000	
JUL	2424.0	70.9	63.2	0.2307E 07	0.2637E 07	3660.5	0.779	1.000	
AUG	9157.0	146.4	60.6	0.4332E 07	0.2637E 07	3287.7	0.901	1.000	
SEP	1920.0	370.0	52.7	0.1110E 08	0.2552E 07	2699.9	1.141	1.000	
OCT	1405.0	710.0	42.1	0.2130E 08	0.2637E 07	2038.8	1.501	0.855	
NOV	1016.0	1660.0	29.6	0.3189E 08	0.2552E 07	1511.6	1.842	0.570	
DEC	810.2	1258.0	21.2	0.4076E 08	0.2637E 07	1181.1	2.028	0.422	
TOTAL		9044.3		0.2713E 05	0.3105E 08	>>>WEIGHTED	AVERAGE	0.638	

>>WEIGHTED AVE PAGE
>>PARAMETERS

DEPENDABLE VARIABLES/CASE STUDIES

COLLECTOR AREA (FT**2)	995.72	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.3461
COLLECTOR TUBE AREA (SQ FT)	99.46	STORAGE SIDE CAPACITY (BTU/HR F)	0.1101
COLLECTOR SIDE TUBE DIA. (FT)	0.1143	COLLECTOR SIDE CONVECTION COEFF.	1145.5925
COLLECTOR SIDE TUBE DIA. (FT)	0.1143	STORAGE SIDE CONVECTION COEFFICIENT	4119.7892
STORAGE SIDE TUBE DIA. (FT)	0.2017	COLLECTOR SIDE FLOW RATE (GPM)	17.3529
COLLECTOR SIDE FLOW RATE (FT**2/HR)	3.7335	STORAGE SIDE FLOW RATE (GPM)	220.6711
STORAGE SIDE FLOW RATE (FT**2/HR)	23.7651	HEAT EXCHANGER EFFECTIVENESS	0.0.0174
HEAT EXCHANGER EFFECTIVENESS	127.40	HEAT EXCHANGER STORAGE FLOW (GPM/AREA)	0.2216
HEAT EXCHANGER STORAGE FLOW (GPM/AREA)	0.0813	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.1931
SOLAR ENERGY DELIVERED (BTU/YEAR)	0.0000	TOTAL ENERGY DEMAND (BTU/YEAR)	0.3621
TOTAL ENERGY DEMAND (BTU/YEAR)	0.1091	ANNUAL AVERAGE SOLAR LEAD FRACTION	0.6382
ANNUAL AVERAGE SOLAR LEAD FRACTION	0.2001	OBJECTIVE: TPO OF SOLAR INVESTMENT	>>>
OBJECTIVE: TPO OF SOLAR INVESTMENT	0.0.0770	HEAT COEFFICIENT (STORAGE F LTR**2)	326.86
HEAT COEFFICIENT (STORAGE F LTR**2)	9.6295	TOTAL INSTALLATION COST (\$)	20765.62
TOTAL INSTALLATION COST (\$)	0.12	COLLECTOR FLOW FACTOR(FPP)	0.5471
COLLECTOR FLOW FACTOR(FPP)			



7-1071

SCALAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN

OF SIGN DATA OPTIMIS/IMPLIS SUMMARY

>>>>>DATA WATCH TO OUTPUT ID NO. 10232
IMCL-1 LWK AUGUST 1979

LOCATION	ERYCE CANYON	JT	COLLECTOR	FEDERAL PRISON I. D	STUDY APPROACH	ANALYSIS
COLLECTION INDEX.....	10		COLLECTOR	TEST RESULTS,		
LATITUDE, DEGREES.....	37.70		SLOPE:			
MEAN TEMP.....	40.27		PARAMETER, FRUL....	0.3830		
INCLUTU/CAY FT #2)	1739.77		INTERCEPT:			
LOAD FACTOR, HDB.....	9044.25		PARAMETER, FRTA....	0.6270		
MEAN CRUPE TEMP.....	55.00		BASE COST, \$/FT #2...	9.40		
					ECCNMC ESTIMATES	
					SYSTEM LIFE (YEARS)...	20.00
					DISCOUNT RATE.....	0.0900
					INFLATION RATE.....	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	FUEL TYPE	BASIS	EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL		0.70	0.50 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELE		0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS		0.70	0.50 (\$/THM)	100000.0 (BTU/THM)	

HEAT LOAD CHARACTERISTICS

Variable	Value
LOAD	0.17
LCSS	500.00
COEFFICIENT (BTU/H ² FT**2)	2099.99
SURFACE HEAT TRANSFER AREA (FT**2)	140.00
LOAD CONDUCTANCE (BTU/DEGREE DAY)	20.00
DOMESTIC HOT WATER ENERGY DEMAND	9.00
ESTIMATED DAILY DWL USAGE (GAL/PER)	1.00
ESTIMATED CFW USERS	
ESTIMATED SHOWER LOAD EFFECTIVENESS	

REFLECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE .....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE .....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR FT*F).....
COLLECTOR SIDE FOULING FACTOR(HR F/RTU)
STORAGE SIDE FOULING FACTOR(HR F/RTU)
HEX TUBE CONDUCTIVITY(BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE(LB/AREA) .....
ESTIMATED GRUONE REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREA).....
ESTIMATED CORRECTION FOR TAU ALPHA PREO.
ESTIMATED INSTALL/LARCOR COST ($/RTAC).....
ESTIMATED HEX COST ($/F**2).....
ESTIMATED STORAGE TANK COST($/LB STORED)
MAINTENANCE (% INSTALLED COST/YR).....

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ANALYSIS

SYSTEM LIFE (YEARS) ..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE	0.1100

1	16.00
6	6.31
1	0.00
0	3.37
1	04.00
6	2.09
1	0.00
0	3.64
0	0.01
0	0.01
2	20.00
1	5.30
0	0.20
1	0.00
0	9.93
1	0.00
5	5.00
0	0.00
0	0.01



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SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>DATA MARCH TO INPUT ID NO. 10232
MOD-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSCLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR THUT FACTOR	SOLAR ENERGY FPACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.2680E 08	0.2637E 07	1408.9	1.921	0.441
FEB	1276.0	1186.0	23.2	0.2419E 08	0.2382E 07	1839.9	1.556	0.531
MAR	1685.0	1114.0	29.1	0.2273E 08	0.2637E 07	2459.2	1.247	0.635
APR	2135.0	821.4	37.6	0.1676E 08	0.2552E 07	3055.9	0.973	0.743
MAY	2454.0	542.0	47.5	0.1106E 08	0.2637E 07	3553.5	0.812	0.851
JUN	2655.0	245.0	56.9	0.5030E 07	0.2552E 07	3750.1	0.747	1.000
JUL	2424.0	76.9	63.2	0.1569E 07	0.2637E 07	3660.5	0.780	1.000
AUG	2157.0	144.4	60.6	0.2946E 07	0.2537E 07	3287.7	0.901	1.000
SEP	1920.0	370.0	52.7	0.7548E 07	0.2552E 07	2699.9	1.142	1.000
OCT	1465.0	710.0	42.1	0.1448E 08	0.2637E 07	2038.8	1.501	0.855
NOV	1016.0	1060.0	29.6	0.2162E 08	0.2552E 07	1511.6	1.852	0.576
DEC	818.2	1358.6	21.2	0.2772E 08	0.2637E 07	1281.1	2.038	0.429
TOTAL		9044.3		0.1845E 09	0.3105E 08	>>>WEIGHTED AVERAGE		0.648

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA	(FT**2)	707.92	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.603E 04
TILT ANGLE (DEG)	...	49.37	STORAGE SIDE CAPACITY (BTU/HR F)	0.845E 05
COLLECTOR SLOPE	...	0.0949	COLLECTOR SIDE CONVECTION COEFF	1230.5281
COLLECTOR SLOPE	...	0.0999	COLLECTOR SIDE CONVECTION COEFFICIENT	3967.5757
COLLECTOR SLOPE	...	0.1770	COLLECTOR SIDE FLOW RATE (GPM)	12.3644
COLLECTOR SLOPE	...	3.8929	STORAGE SIDE FLOW RATE (GPM)	169.5895
COLLECTOR SLOPE	...	22.3075	NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0175
COLLECTOR SLOPE	...	120.85	NORMALIZED STORAGE FLOW (GPM/AREA)	0.239C
COLLECTOR SLOPE	...	0.0177	HEAT EXCHANGE EFFECTIVENESS	0.8455
COLLECTOR SLOPE	...	0.0050	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.140E 09
COLLECTOR SLOPE	...	0.943E 05	TOTAL ENERGY DEMAND (BTU/YEAR)	0.216E 09
COLLECTOR SLOPE	...	0.245E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6482
COLLECTOR SLOPE	...	0.0114	OBJECTIVE: NPV OF SOLAR INVESTMENT	0.148E 05
COLLECTOR SLOPE	...	9.6476	HEX COEFFICIENT (BTU/HR F FT**2)	32C.46
COLLECTOR SLOPE	...	9.14	TOTAL INSTALLATION COST (\$)	1478C.37
COLLECTOR SLOPE	...	...	COLLECTOR FLOW FACTOR(FPP)	0.5472



DE-5161 DATA OPTIMIS/INPUTS SUMMARY -

>>>>DATA MATCH TO OUTPUT ID NO. 10233
 PADD-1 LWK AUGUST 1975

WILSON

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/FT*F).....
COLLECTOR SIDE FLOWING FACTOR(HR./RTU).....
STORAGE SIDE FLOWING FACTOR(HR./RTU).....
HEX TUBE CONDUCTIVITY(RTU/HR.FT).....
ESTIMATED OPTIMUM STORAGE(LB/APEAC).....
ESTIMATED PUMPING POWER(KWH/APEAC).....
ESTIMATED CORRECTION FOR TAIL ALPHA PLED.....
ESTIMATED INSTALL LABOR COST (L/APEAC).....
ESTIMATED HEX COST (1/FT**2).....
ESTIMATED STORAGE TANK COST(4/LB STCFD).....
MAINTENANCE (3/INSTALLED COST/YR).....

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>>>>DATA MATCH TO INPUT ID NO. 10253
(JAN)-1 CLK AUGUST 1979

THE UNIVERSITY OF CHICAGO

>>>WEIGHTED AVERAGE
OT. IJK PARAMETERS



STUDY APPROACH

COLLECTOR SOLARNETICS

LOCATION	LODGE CITY	KAN
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99		
100		

ECONOMIC ESTIMATES

COLLECTOR TEST RESULTS,

SYSTEM LIFE (YEARS) ..	20.00
DISCOUNT RATE	0.1150
INFLATION RATE	0.1050

SELECTED PARAMETERS

ENERGY COMPARATIVE ESTIMATES

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR**F*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).....
COLLECTOR SIDE FILLING FACTOR(HR F/BTU).....
STORAGE SIDE FILLING FACTOR(HR F/BTU).....
HEX TUBE CONDUCTIVITY(BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE(LB/AREAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PREC.....
ESTIMATED INSTALL/LAECR COST ($/AREAC).....
ESTIMATED HEX COST ($/FT*2).....
ESTIMATED STORAGE TANK COST($/LP STORED).....
MAINTENANCE (% INSTALLED COST/YR).....

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TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	0.25
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	5000.00
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	30000.00
					140.00
					20.00
					6.00
					1.00

176.00
60.81
1.0000
0.3870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
0.93
10.00
5.00
0.08
0.01



S O L U D - 1

SCLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY, KAN

 >>>> DATA MATCH TO INPUT ID NO. 11111
 JMC0-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DAY LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	627.0	1109.0	29.2	0.3327E 08	0.2637E C7	1405.3	1.803	0.051
FEB	1122.0	875.3	34.0	0.2626E 08	0.2382E C7	1836.6	1.529	0.125
MAR	1477.0	739.2	41.2	0.2213E 08	0.2637E C7	2456.6	1.228	0.172
APR	1486.0	354.7	53.7	0.1064E 08	0.2552E C7	3094.4	1.002	0.318
MAY	2070.0	128.2	64.0	0.3846E 07	0.2637E C7	3553.5	0.868	0.562
JUN	2358.0	15.4	74.0	0.4520E 06	0.2552E C7	3750.3	0.812	0.934
JUL	2296.0	1.4	79.0	0.4200E 05	0.2637E C7	3660.4	0.837	0.996
AUG	2055.0	1.9	77.5	0.5700E 05	0.2637E C7	3286.7	0.945	0.957
SEP	1687.0	70.9	67.5	0.2127E 07	0.2552E C7	2697.6	1.141	0.738
OCT	1301.0	275.4	57.1	0.8262E 07	0.2637E C7	2035.7	1.438	0.383
NOV	893.0	701.0	41.7	0.2103E 08	0.2552E C7	1508.0	1.728	0.142
DEC	731.9	1011.7	32.4	0.3035E 08	0.2637E C7	1277.5	1.894	0.090
TOTAL		5284.1		0.1585E 09	0.3105E C8			

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS		>>>WEIGHTED AVERAGE	
COLLECTOR AREA (FT**2)	162.13	CAPACITY (BTU/HR)	F)	0.163E	04
COLLECTOR TILT ANGLE (DEG)	42.70	CAPACITY (BTU/HR)	F)	0.296E	05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0625	CONVECTION COEFF.		518.	0244
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0724	CONVECTION COEFFICIENT		3532.	7219
SOLAR SIDE TUBE (HEX) INNER DIA. (FT)	0.1217	FLOW RATE (GPM)		3.	3477
COLLECTOR SIDE TUBE FLUID VELOCITY (FT/SEC)	2.4313	FLOW RATE (GPM)		59.	3792
STORAGE SIDE FLUID VELOCITY (FT/SEC)	17.6000	CAPACITY (GPM/AREAC)		0.	2662
HEAT EXCHANGER LENGTH (FT)	53.82	CAPACITY (GPM/AREAC)		0.	8460
HEX ANNUAL LIQUID CIRCULATION CONSTRAINTS (FT)	0.0493	EFFICIENCY		0.	411E
COLLECTOR SIDE TUBE DIFFERENCE (FT)	0.0099	DELIVERED (BTU/YEAR)		0.	190E
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	0.388E	DEMAND (BTU/YEAR)		0.	2168
STORAGE SIDE REYNOLDS NUMBER	0.123E	ANNUAL AVERAGE SOLAR LOAD FRACTION		0.	153E
CAPACITY RATE (GMIN/C MAX)	0.0952	PERCENTAGE OF SOLAR INVESTMENT		298.	9.16
FLOW PARAMETER Z1 (GCP/FPUL)	9.7027	HEX COEFFICIENT (BTU/HR F FT**2)		484.	9.16
FLOW PARAMETER Z1 (GCP/FPUL)	9.19	TOTAL INSTALLATION COST (\$)		0.	5475







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S O L O A D - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY
>>>>DATA MATCH TO OUTPUT ID NO. 11113
IMOD-1 LWK AUGUST 1979

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SOLAR ENERGY OPTIMIZATION ANALYSIS UR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 11113
IMDD-1 LWK AUGUST 1979

LOCATION	DODGE CITY	KAN	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		11	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....		37.77	SLOPE:		
MEAN TEMPERATURE.....		54.31	PARAMETER, FRUL....		
INSOL (Btu/DAY FT**2)		1558.71	INTERCEPT:		
LCC FACTOR, FCC.....		5284.10	PARAMETER, FRIA....		
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT**2...		
				ECONOMIC ESTIMATES	
				SYSTEM LIFE (YEARS)...	20.00
				DISCOUNT RATE.....	0.1150
				INFLATION RATE.....	0.1050

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASL EFFICIENCY	CUST	HEATING VALUE	UCL
1	CIL	0.70	0.90 (\$/GAL)	14200.0 (BTU/GAL)	
2	EAL	0.59	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	

HEAT LOAD CHARACTERISTICS

LOAD	LCSS	Coefficient (HTU/HR-F	FT**2) ..	0.09
LOAD	SURFACE	FEAT	TOTALSFER AREA (FT**2) ..	5000.00
LCAB	CONDUCTANCE	(BTU/DEG F DAY)		10799.99
LCOMESTIC	FTT	WATER (GHW)	DESIGN TEMP.	140.00
ESTIMATED	DAILY	GHW	USAGE (GAL/PER) ..	20.00
ESTIMATED	GHW	USERS	(PER) ..	6.00
ESTIMATED	SURGE	TU	LOAD EFFECTIVENESS:	1.00

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY (LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F).....
COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY (LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR (HR F/BTU).....
COLLECTOR SIDE FOULING FACTOR (HR F/FTU).....
COLLECTOR HEAT EXCHANGER CONDUCTIVITY (BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE (LB/AREA*F).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER (KWH/AREA*F).....
ESTIMATED CORRECTION FOR TAU ALPHA PREC.....
ESTIMATED INSTALL/LABOR COST ($/AREA*F).....
ESTIMATED MIX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST ($/LF*STORED).....
ESTIMATED MAINTENANCE (% INSTALLED COST/YR).....

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LOCATION	BUDGE CITY	KAN	COLLECTOR	SOLARNET	ICS	STUDY APPROACH	ANALYSIS

ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)...	20.00
DISCOUNT RATE.....	0.1150
INFLATION RATE.....	0.1050



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RESULTS OF ANALYSIS FOR DOUG CITY KAN

>>>>DATA MATCH TO INPUT ID NC. 11113
'JMCC-1 LMK AUGUST 1979

>>WEIGHTED AVERAGE
CT,IR PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA	(FT**2)	>>>	121.97	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.122E 04
COLLECTOR TILT	ANGLE (DEG)	>>>	40.34	STORAGE SIDE CAPACITY (BTU/HR F)	0.271E 05
COLLECTOR SIDE	TUBE INNER DIA. (FT)	>>>	0.0491	COLLECTOR SIDE CONVECTION COEFF.	1124.38253
COLLECTOR SIDE	TUBE OUTER DIA. (FT)		0.0541	STORAGE SIDE CONVECTION COEFFICIENT	3251.7253
STORAGE SIDE	TUBE(HEX) INNER DIA. (FT)		0.1120	COLLECTOR SIDE FLOW RATE (GPM)	2.5028
COLLECTOR SIDE	FLUID VELOCITY (FT/SEC)		2.9+82	STORAGE SIDE FLOW RATE (GPM)	54.3385
STORAGE SIDE	FLUID VELOCITY (FT/SEC)		16.0047	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0205
HEAT EXCHANGER	LENGTH (FT)		49.79	HEAT EXCHANGE EFFECTIVENESS	0.4455
HEX ANNUAL DIAMETER DIFFERENCE	(FT)	//////////	0.0580	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.8545
COLLECTOR SIDE	TUBE LIA. DIFFERENCE(FT)		0.0050	TOTAL ENERGY DELAID (BTU/YEAR)	0.307E 08
COLLECTOR SIDE	REYNOLDS NUMBER		0.269E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3485
STORAGE SIDE	REYNOLDS NUMBER		0.131E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT	>>>
CAPACITY RATIO	(CMIN/CMAX)		0.0491	HEX COEFFICIENT (BTU/HR F FT**2)	0.143E 04
FLOW PARAMETER	Z1(CCP/FRUL)		9.6419	TOTAL INSTALLATION COST (\$)	314.54
FLOW PARAMETER	Z1(CCP/FRPU)		9.13	COLLECTOR FLOW FACTOR(FPP)	3646.53
					0.9472



DIGITAL DATA OPTIMIS/IMPLTS SUMMARY

>>>>DATA MAYCH 10 00. 11221
1000-1 LK AUGUST 1979

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SCALAR ENERGY OF PLASMA IN ANALYSIS OF DISPERSED

RESULTS OF ANALYSIS FOR LODGE CITY FALL

>>>> DATA PATCH TO 140110 10 110. 112211
JMC0-1 LEK AUGUST 1979

JMCD-1 LHK AIGI ST 1979

MONTH	HORIZONTAL INSULATION	FLATROD DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	QHW LOAD	EXTREM- TEMPERATURAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FACTOR
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	127.0	1109.0	29.2	0.3327E 08	0.2637E 07	1405.3	1.670	0.277
FEB	1127.0	875.5	34.0	0.2626E 08	0.2382E 07	1836.6	1.555	0.363
MAR	1477.0	730.2	41.2	0.2218E 08	0.2037E 07	2456.6	1.211	0.462
APR	1880.0	354.7	53.7	0.1064E 08	0.2552E 07	3094.4	0.954	0.722
MAY	2070.0	128.2	64.0	0.3846E 07	0.2637E 07	3553.5	0.805	0.941
JUN	2458.0	15.4	74.0	0.4620E 06	0.2552E 07	3750.3	0.742	1.000
JUL	2896.0	1.4	79.0	0.4203E 05	0.2637E 07	3660.4	0.769	1.000
AUG	2655.0	1.0	77.5	0.5700E 05	0.2637E 07	3286.7	0.949	1.000
SEP	1627.0	70.9	67.5	0.2127E 07	0.2552E 07	2697.6	1.111	1.000
OCT	1331.0	275.4	57.1	0.3262E 07	0.2637E 07	2335.7	1.451	0.849
NOV	893.7	701.0	41.7	0.2103E 03	0.2552E 07	1508.0	1.784	0.511
DEC	731.9	1011.7	32.4	0.3035E 08	0.2637E 07	1277.5	1.575	0.275
TOTAL		5284.1		0.1585E 09	0.3105E 08	>>>NOT IGTIFIED	AVI PAGE	0.467

DISIGI VAGIARI SCHEFFERS

COLLECTOR AREA	AREA (FT**2)	SSS	COLLECTOR TYP	ANG1 (DEG)	SSS	5/5,06	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.574E 04
COLLECTOR SIDE	ROBI INNER DIA. (FT)	>>>	50.96	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	50.96	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
COLLECTOR SIDE	ROBI OUTER DIA. (FT)	>>>	0.0047	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.0047	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	0.0047	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.0047	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	0.1679	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.1679	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	3.7248	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	3.7248	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	21.5183	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	21.5183	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	114.51	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	114.51	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	0.0602	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.0602	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	0.0095	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.0095	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	0.5095	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.5095	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	5.2095	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	5.2095	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	0.0341	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	0.0341	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	9.0070	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	9.0070	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04
STORAGE SIDE	COLLECTOR DIA. (FT)	>>>	9.10	COLLECTOR SIDE CAPACITY (BTU/HR F)	>>>	9.10	STORAGE SIDE CAPACITY (BTU/HR F)	0.574E 04



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SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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* * * DE SIGN DATA OPTIONS/INPLTS SUMMARY
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>>>DATA MATCH TO OUTPUT ID NC 11242
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MOD-1 LWK AUGUST 1975
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LOCATION	DODGE CITY	KAN	COLLECTOR AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		11	COLLECTOR TLSF RESULTS,		
LATITUDE, DEGREES.....		37.77	SLOPE:		
MEAN TEMPERATURE.....		54.31	PARA METER, FEOL....		
INSOL (BTU/DAY FT**2)		1558.71	INTERCEPT:		
LOAD FACTOR, FDL.....		5284.10	PARA METER, FRTA....		
MEAN GRCOND TEMP.....		55.00	BASE COST, \$/FT**2...		
				ECONOMIC ESTIMATES	
				SYSTEM LIFE(YEARS)...	20.00
				DISCOUNT RATE	0.0900
				INFLATION RATE	0.1100

ENERGY COMPARATIVE ESTIMATES SELECTED PARAMETERS

TYPE ENERGY BASE		OIL		COLLECTOR		FLUID MEAN TEMPERATURE		
INDEX	TYPE	EFFICIENCY	COST	HEATING	VALUE	DENSITY (LB/FT**3)	SPECIFIC HEAT (BTU/LB*F)	
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)				176.66
2	ELF	0.99	0.95 (\$/NH)	3413.0 (BTU/KWH)				60.81
3	GAS	0.70	0.40 (\$/TH)	100000.0 (BTU/TH)				1.0000
								0.3870
								104.00
								62.09
								1.0000
								0.3640
								0.0010

HEAT LOAD CHARACTERISTIC

LOAD LOSS CH-FIELD	(RDU/RK F F T**2) ..		
LOAD SURFACE FLAT T LAUC	FED A LA C T **2)		
		0.17	
HUX TORP CONDUCTIVITY	(RU/RH F F T F).....		220.06
ESTIMATED OPTIMUM STERAGE	(LP/AREA)		15.3C
ESTIMATED GROUND STERAGE			

LOAD CONDUCTANCE (BTU/DEG F DAY)	..	2039.99	ESTIMATED PUMPING POWER (KW/HARFAC).....
DYSTETIC HOT WATER DESIGN TEMP.	..	140.00	CORRECTION FACTOR TAU ALPHA PREC.....
ESTIMATED DAILY ENERGY USE (GAL/PEP)	..	20.00	ESTIMATED INSTALLATION LABOR COST (\$/HARFAC).....
ESTIMATED DHW USERS (PER)	..	0.00	HEX CHSE (\$/T*H*).....
ESTIMATED STORAGE TO LOAD EFFECTIVENESS	..	1.00	ESTIMATED STORAGE TANK COST (\$/LA STORED).....
			MAINTENANCE (% INSTALLED COST/YR).....
			1.0000
			1.0000
			10.000
			5.000
			0.008
			0.0010



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SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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RESULTS OF ANALYSIS FOR DODGE CITY      KAN
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>>>DATA MATCH TO INPUT ID NC. 11222
MOD-I LWK AUGUST 1975

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MONTH	HORIZONTAL INSULATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE		HEATING LOAD		DHW LOAD		EXTRA-TERRESTRIAL INSULATION		COLLECTOR TILT FACTOR		SOLAR ENERGY FRACTION	
	BTU/DAY	FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH	BTU/DAY	FT**2	
JAN	827.0		1109.0	29.2	0.2262E	08	0.2637E	C7	1405.3		1.866		0.281			
FEB	1122.0		875.3	34.0	0.1780E	08	0.2382E	C7	1836.6		1.554		0.367			
MAR	1477.0		759.2	41.2	0.1508E	08	0.2637E	C7	2456.6		1.213		0.464			
APR	1830.0		354.7	53.7	0.7230E	07	0.2552E	C7	3054.4		0.958		0.705			
MAY	2070.0		128.2	64.0	0.2615E	07	0.2637E	C7	3553.5		0.809		0.916			
JUN	2358.0		15.4	74.0	0.3142E	06	0.2552E	C7	3750.3		0.747		1.000			
JUL	2296.0		1.4	77.0	0.2650E	05	0.2637E	C7	3660.4		0.774		1.000			
AUG	2055.0		1.9	77.5	0.3876E	05	0.2637E	C7	3286.7		0.893		1.000			
SEP	1687.0		70.9	67.9	0.1446E	07	0.2552E	C7	2657.6		1.114		1.000			
OCT	1301.0		275.4	57.1	0.5018E	07	0.2637E	C7	2035.7		1.451		0.827			
NOV	393.9		701.0	41.7	0.1430E	08	0.2552E	C7	1508.0		1.781		0.610			
DEC	731.9		1711.7	32.4	0.2064E	08	0.2637E	C7	1277.5		1.971		0.277			
TOTAL			5284.1		0.1078E	09	0.5105E	08								
>>>WEIGHTED AVERAGE																
OTHER PARAMETERS																
COLLECTOR AREA (FT**2)				>>>	410.70		COLLECTOR SIDE CAPACITY (BTU/HR)									0.416E 04
COLLECTOR TILT ANGLE (DEG)				>>>	50.40		STORAGE SIDE CAPACITY (BTU/HR)									0.456E C5
COLLECTOR TUBE INNER DIA. (FT)				>>>	0.0757		COLLECTOR SIDE CONVECTION COEFF.									1373.8562
COLLECTOR TUBE OUTER DIA. (FT)					0.0307		STORAGE SIDE CONVECTION COEFFICIENT									3614.0764
COLLECTOR TUBE REYNOLDS NUMBER					0.1424		COLLECTOR SIDE FLOW RATE (GPM)									8.5305
COLLECTOR TUBE REYNOLDS NUMBER					4.2221		STORAGE SIDE FLOW RATE (GPM)									91.6591
COLLECTOR TUBE REYNOLDS NUMBER					18.9100		NORMALIZED COLLECTOR FLOW (GPM/AREA)									0.0205
COLLECTOR TUBE REYNOLDS NUMBER					73.09		NORMALIZED STORAGE FLOW (GPM/AREA)									0.2200
COLLECTOR TUBE REYNOLDS NUMBER							HEAT EXCHANGER EFFECTIVENESS									0.7554
HEX ANNUAL DIAPHRAGM DIFFERENCE (FT)					0.0616		SOLAR ENERGY DELIVERED (BTU/YEAR)									0.669E 08
COLLECTOR TUBE DIA. DIFFERENCE (FT)					0.0050		TOTAL ENERGY DEMAND (BTU/YEAR)									0.139E 09
COLLECTOR TUBE REYNOLDS NUMBER					0.815E 09		ANNUAL AVERAGE SOLAR LOAD FRACTION									0.4817
COLLECTOR TUBE REYNOLDS NUMBER					0.165E 06		OBJECTIVE: NPV OF SOLAR INVESTMENT									0.655E 04
CAPACITY RATIO (CMIP/CMAX)					0.0911		HEX COEFFICIENT (BTU/HR F FT**2)									333.51
FLOW PARAMETER 22(CCP/RII)					9.0103		TOTAL IS FRACTION (COST)									7495.21
FLOW PARAMETER 21(GCP/RIPII)					9.10		COLLECTOR FLOW FACTOR (HFP)									0.9470



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*****          SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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*****          DESIGN DATA OPTIONS/INPUTS SUMMARY
*****
*****          ***** >>>DATA MATCH<<<*****
*****          ID NO. 11223
*****          IMOD-1 LWN AUGUST 1975

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LOCATION	JUDGE CITY	KAN	COLLECTOR	AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		11	COLLECTOR TEST RESULTS,			
LATITUDE, DEGREES.....		37.77	SLOPE:			
MEAN TEMPERATURE.....		54.31	PARAMETER, FRUL....	1.0350		
INSOL (BTU/DAY FT**2)		1558.71	INTERCEPT:			
LOAD FACTOR, HDD.....		5284.10	PARAMETER, FRTA....	0.6380	SYSTEM LIFE(YEARS)...	20.00
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT**2...	6.55	DISCOUNT RATE.....	0.0900
					INFLATION RATE.....	C.1100

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	CHL	0.70	0.30 (\$/GAL)	14200.0 (BTU/GAL)	
2	FLU	0.99	0.65 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THU)	10000.0 (BTU/THU)	

HEAT LEAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.09
LCAC SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	10739.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	20.00
ESTIMATED DHW USERS (PER) ..	6.00
ESTIMATED STRIKE PLOT EFFECTIVENESS:	1.00

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COLLECTOR FLOW MEAN TEMPERATURE.....
COLLECTOR FLOW DENSITY(LB/FT**3).....**F3)
COLLECTOR FLOW SPECIFIC HEAT(BTU/LB**F).....**F)
COLLECTOR FLOW CONDUCTIVITY(BTU/HR**FT**F)
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY(LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT(BTU/LB**F).....
STORAGE FLOW CONDUCTIVITY(BTU/HR FT F)
COLLECTOR SIDE FOULING FACTOR(HR I/BTU)
STORAGE SIDE FOULING FACTOR(HR F/BTU)
HEX TUBE CONDUCTIVITY(BTU/HR FT F).....
ESTIMATED OPTIMUM STORAGE(LB/AREA).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AREA).....
ESTIMATED CORRECTION FOR TAU ALPHA PEED.....
ESTIMATED INSTALL/LABCF COST ($/AREA).....
ESTIMATED FIX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST (4/LP STCPE)
ESTIMATEANCE OF INSTALLED COST/YR).....

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1176.00	1176.00
60.81	60.81
1.0000	1.0000
0.3870	0.3870
104.00	104.00
62.05	62.05
1.0000	1.0000
0.3640	0.3640
0.0010	0.0010
0.0010	0.0010
220.00	220.00
15.30	15.30
0.20	0.20
1.0000	1.0000
0.93	0.93
10.0000	10.0000
5.00	5.00
0.08	0.08
0.0010	0.0010



S O L U A T I O N - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

>>>> DATA MARCH TO INPUT 10 40 11223
JMC0D-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DIM LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	1276.0	1109.0	29.2	0.1193E 08	0.2637E 07	1405.3	1.860	0.322
FEB	1124.0	875.5	34.0	0.9453E 07	0.2382E 07	1836.6	1.552	0.415
MAR	1477.0	739.2	41.2	0.7983E 07	0.2637E 07	2456.6	1.215	0.514
APR	1866.0	354.7	53.7	0.3631E 07	0.2552E 07	3094.4	0.964	0.733
MAY	2070.0	128.2	64.0	0.1365E 07	0.2637E 07	3553.5	0.817	0.890
JUN	2358.0	15.4	74.0	0.1553E 06	0.2552E 07	3750.3	0.756	1.000
JUL	2296.0	1.4	79.0	0.1512E 05	0.2637E 07	3660.4	0.783	1.000
AUG	2055.0	1.9	77.5	0.2052E 05	0.2637E 07	3286.7	0.900	1.000
SEP	1687.0	70.9	67.5	0.7657E 06	0.2552E 07	2697.6	1.118	0.993
OCT	1301.0	275.4	57.1	0.2974E 07	0.2637E 07	2035.7	1.450	0.829
NOV	853.6	701.0	41.7	0.7571E 07	0.2552E 07	1508.0	1.776	0.452
DEC	731.9	1011.7	32.4	0.1095E 08	0.2637E 07	1277.5	1.963	0.316
TOTAL		5284.1		0.5707E 08	0.3105E 08			0.547

>>>WEIGHTED AVERAGE
OTHER PARAMETERS

COLLECTOR AREA (FT**2)	280.51	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.285E 04
COLLECTOR TILT ANGLE (DEG)	49.42	STORAGE SIDE CAPACITY (BTU/HR F)	0.414E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0728	COLLECTOR SIDE CONVECTION COEFF	1050.6305
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0778	STORAGE SIDE CONVECTION COEFFICIENT	3579.9036
STC/FABL SIDE THERMCK) INNER DIA. (FT)	0.1371	COLLECTOR SIDE FLOW RATE (GPM)	5.8405
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	3.1325	STORAGE SIDE FLOW RATE (GPM)	83.1504
STORAGE SIDE FLUID VELOCITY (FT/SEC)	18.5024	NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0208
HEAT EXCHANGER LENGTH (FT)	78.32	NORMALIZED STORAGE FLOW (GPM/AREA)	0.2566
HEAT EXCHANGER LENGTH (FT)	0.0594	HEAT EXCHANGER EFFECTIVENESS	0.8494
HEX ANNUAL DIAMETER DIFFERENCE (FT)	0.0050	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.482E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	0.0010	TOTAL ENERGY DEMAND (BTU/YEAR)	0.881E 08
COLLECTOR SIDE REYNOLDS NUMBER	0.081E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.5467
STORAGE SIDE REYNOLDS NUMBER	0.155E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT	0.503E 04
CAPACITY RATIO (CMIN/CMAX)	0.0638	HEX COEFFICIENT (BTU/HR F FT**2)	313.52
FLOW PARAMETER Z2 (G/G/FT**2)	9.78*1	TOTAL INSTALLATION COST (\$)	5075.35
FLOW PARAMETER Z1 (G/G/FT**2)	9.28	COLLECTOR FLOW FACTOR (FPP)	0.9480



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN									
DESIGN DATA OPTIONS/INPUTS SUMMARY									
LOCATION	COUNTRY	CITY	KAN	COLLECTOR FEDERAL PRISM I. D.	STUDY APPROACH	ANALYTICS			
>>>> DATA MATCH TO CURPUL ID NO. 11232									
MJD-1 LMK AUGUST 1979									
COLLECTOR TEST RESULTS,									
LOCATION INDEX.....	11								
LATITUDE, DEGREES.....	37.77								
MEAN TEMPERATURE.....	54.31			0.8820					
INSOL (BTU/DAY FT**2)	1558.71								
LOAD FACTOR, HDD.....	5284.10			0.6270					
MEAN GROUND TEMP.....	55.00			9.40					
ECONOMIC ESTIMATES									
SYSTEM LIFE (YEARS)...									
DISCOUNT RATE.....									
INFLATION RATE.....									
20.00									
0.0900									
0.1100									
ENERGY COMPARATIVE ESTIMATES									
TYPE ENERGY BASE.....	HEATING VALUE								
INDEX									
1	GIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)					
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)					
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)					
HEAT LOAD CHARACTERISTICS									
LOAD LOSS COEFFICIENT (BTU/HR F. FT**2)...	0.17								
LOAD SURFACE HEAT TRANSFER AREA (FT**2)...	5000.00								
LOAD CONDUCTANCE (BTU/DEG F DAY)...	20393.99								
DOMESTIC HOT WATER (GWH) DESIGN TEMP.	140.00								
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00								
ESTIMATED DHW USERS (PER).....	6.00								
ESTIMATED STORAGE TANK EFFECTIVENESS.....	1.00								
SELECTED PARAMETERS									
COLLECTOR FLUID MEAN TEMPERATURE.....									
COLLECTOR FLUID DENSITY (LB/FT**3).....									
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)...									
COLLECTOR FLOW CONDUCTIVITY (BTU/FT**F)...									
STORAGE FLUID MEAN TEMPERATURE.....									
STORAGE FLUID DENSITY (LB/FT**3).....									
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)...									
STORAGE FLUID CONDUCTIVITY (BTU/HR FT F)...									
COLLECTOR SIDE FOULING FACTOR (HR F/FTU)									
STORAGE SIDE FOULING FACTOR (HR F/FTU)									
HEX TUBE CONDUCTIVITY (BTU/HR FT F).....									
ESTIMATED IPT MIN STORAGE (LB/AREAC)									
ESTIMATED GROUND REFLECTANCE.....									
ESTIMATED PUMPING POWER (KWH/AREAC).....									
ESTIMATED CORRECTION FOR TAU ALPHA PRED.									
ESTIMATED INSTALL/LABOR COST (\$/AREAC)...									
ESTIMATED HEX COST (\$/FT**2).....									
ESTIMATED STORAGE TANK COST (\$/LF STORED)									
MAINTENANCE (% INSTALLED COST/YR).....									
176.00									
50.81									
1.0000									
0.3870									
104.00									
62.05									
1.0000									
0.3640									
0.0010									
0.0010									
220.00									
15.30									
0.20									
1.0000									
0.92									
10.00									
5.00									
0.08									
0.0010									

LOCATION	CUDGE CITY	KAN	COLLECTOR FEDERAL PRISON I. D	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		11	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....		37.77	SLOPE:		
MEAN TEMPERATURE.....		54.31	PARAMETER, FRUL....		
INSOL (BIL/DAY FT*2)		1558.71	INTERCEPT:	SYSTEM LIFE(YEARS)...	20.00
LOAD FACTOR, HDD.....		5284.10	PARAMETER, FKTA....	DISCOUNT RATE.....	0.0900
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT**2...	INFLATION RATE.....	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENVELOPE TYPE	EASE EFFICIENCY	COST (\$/GAL)	HEATING VALUE (BTU/GAL)	GIL VALUE (BTU/KWH)	COLLECTOR FLUID MEAN TEMPERATURE (°F)	COLLECTOR FLUID DENSITY (LB/FT³)	COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)	COLLECTOR FLUID CONDUCTIVITY (BTU/FT²*FT*F)	STORAGE FLUID MEAN TEMPERATURE (°F)
1	CIL	0.70	0.90	142000.0	3413.0	100000.0	1.00000	0.3270	104.00	
2	ELE	0.99	0.05	3413.0	100000.0	100000.0	1.00000	0.3270	104.00	
3	GAS	0.70	0.40	100000.0	3413.0	100000.0	1.00000	0.3270	104.00	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HK F FT**2) ..	0.17	STORAGE SIDE FOUling FACTOR (HK F/FTU)	0.0010
LOAD SURFACE FET TRANSFER AREA (FT**2) ..	5000.00	HEX TUBE CONDUCtIVITY (BTU/HR FT F) ..	220.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	20390.99	ESTIMATED OPTIMUM STORAGE (LB/ARFAC) ..	15.30
DOMESTIC HOT WATER (GAL) ..	140.00	ESTIMATED GROUND REFLECTANCE ..	0.20
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	20.00	ESTIMATED PUMPING POWER (KWH/AFAC) ..	1.0000
ESTIMATED DHW USERS (PER) ..	6.00	ESTIMATED CORRECTION FOR TAU ALPHA PRED.	10.00
ESTIMATED STORAGE LOSS COEFFICIENT (BTU/HR F FT**2) ..	1.00	ESTIMATED HEX COST (\$/FT**2) ..	5.00
		ESTIMATED STORAGE TANK COST (\$/LB FOR LB)	0.08

ENERGY COMPARATIVE ESTIMATES

TYPE	ENTRY	EASE	EFFICIENCY	COST	HEATING	VALUE	OIL
INDEX	TYPE						
1	CIL	0.70	0.90(\$/GAL)	142000.0	(BTU/GAL)		
2	ELE	0.99	0.05(\$/KWH)	3413.0	(BTU/KWH)		
3	GAS	0.70	0.40(\$/TIN)	100000.0	(BTU/TIN)		
HEAT LOAD CHARACTERISTICS							

LOAD	LOSS	Coefficient	(BTU/HK.F	FT**2)	..	0.17	
LOAD	SURFACE	FENT	TRANSFER	AREA	(FT**2)	..	5000.00
LOAD	CONDUCTANCE	(BTU/DEG.F	DAY)	..	..	20390.99	
DOMESTIC	HOT	WATER	(GWH)	DESIGN	TEMP.	..	140.00
ESTIMATED	DAILY	DHW	IS	LOAD	(GAL/PER)	..	20.00
ESTIMATED	DHW	USERS	(PER)	..	..	6.00	
ESTIMATED	SPACE	HEAT	LOAD	EFFICIENCY	..	1.00	

COLLECTOR	FLUID	MEAN	TEMPERATURE	..	..	176.00	
COLLECTOR	FLUID	DENSITY	(LB/FT**3)	..	..	60.81	
COLLECTOR	FLUID	SPECIFIC	HEAT	(BTU/LB*F)	..	1.0000	
COLLECTOR	FLUID	CONDUCTIVITY	(BTU/IN*FT*F)	..	..	0.3870	
STORAGE	FLUID	MEAN	TEMPERATURE	..	..	104.00	
STORAGE	FLUID	DENSITY	(LB/FT**3)	..	..	62.05	
STORAGE	FLUID	SPECIFIC	HEAT	(BTU/LB*F)	..	1.0000	
STORAGE	FLUID	CONDUCTIVITY	(BTU/IN*FT*F)	..	..	0.3640	
COLLECTOR	SIDE	FILLING	FACTOR	(HR.F/RTU)	..	0.0010	
STORAGE	SIDE	FILLING	FACTOR	(HR.F/RTU)	..	0.0010	
HEX	TUBE	CONDUCTIVITY	(BTU/HR.F	FT)	..	220.00	
ESTIMATED	OPTIMUM	STORAGE	(LB/AREA)	..	..	15.30	
ESTIMATED	GROUND	REFLECTANCE	..	..	..	0.20	
ESTIMATED	PUMPING	POWER	(KWH/AF*AC)	..	..	1.0000	
ESTIMATED	CORRECTION	FOR	TAY	ALPHA	PRED.	..	0.92
ESTIMATED	INSTALL	/LABOR	COST	(\$/AF*AC)	..	10.00	
ESTIMATED	HEX	COST	(\$/FT**2)	..	..	5.00	
ESTIMATED	STORAGE	TANK	COST	(\$/LF	STOR	..	0.08
MAINTENANCE	%	INSTALL	COST	(1/100	..	0.0010	



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**          S U L L A C - 1
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** SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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** RESULTS OF ANALYSIS FOR DODGE CITY KAN
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** * * * * *
** >>>>> ARA MATCH TO INPUT ID NC. 11232
**                                     MOD-1 LWK AUGUST 1975

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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	OUR LOAD	EXTRA- TERRSTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FACTOR
	BTU/DAY FT**2	LEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.2202E 08	0.2037E 07	1405.2	1.861	0.258
FEB	1122.0	875.3	34.0	0.1736E 08	0.2382E 07	1836.6	1.553	0.336
MAR	1477.0	739.2	41.2	0.1508E 08	0.2637E 07	2456.6	1.215	0.429
APR	1886.0	354.7	53.7	0.7236E 07	0.2552E 07	3094.4	0.962	0.673
MAY	2070.0	128.2	64.0	0.2615E 07	0.2637E 07	3553.5	0.815	0.914
JUN	2358.0	15.4	74.0	0.3142E 06	0.2552E 07	3750.3	0.753	1.000
JUL	2550.0	1.4	79.0	0.2850E 05	0.2637E 07	3660.4	0.780	1.000
AUG	2055.0	1.9	77.5	0.3676E 05	0.2637E 07	3286.7	0.898	1.000
SEP	1687.0	70.9	67.9	0.1745E 07	0.2552E 07	2697.6	1.117	1.000
OCT	1301.0	275.4	57.1	0.5613E 07	0.2537E 07	2035.7	1.450	0.793
NOV	893.6	701.0	41.7	0.1430E 08	0.2552E 07	1508.0	1.777	0.379
DEC	731.5	1011.7	32.4	0.2064E 08	0.2637E 07	1277.5	1.965	0.256
TOTAL		5284.1		0.1078E 09	0.3105E 08	>>>WEIGHTED AVERAGE		0.457

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.305E 04
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR F)	0.367E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFF.	1137.0083
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFF.(INT)	3551.4089
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)	>>>	COLLECTOR SIDE FLOW RATE (GPM)	6.2496
COLLECTOR SIDE FLOW VELOCITY (FT/SEC)	>>>	STORAGE SIDE FLOW RATE (GPM)	13.6801
STORAGE SIDE FLOW VELOCITY (FT/SEC)	>>>	NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0173
HEAT EXCHANGER LENGTH (FT)	>>>	NORMALIZED STORAGE FLOW (GPM/AREA)	0.2042
HEAT EXCHANGER DIAMETER (FT)	>>>	HEAT EXCHANGER EFFICIENCY	0.7658
HEX ANNUAL DIAMETER DIFFERENCE (FT)	>>>	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.634E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	>>>	TOTAL ENERGY DEMAND (BTU/YEAR)	0.139E 09
COLLECTOR SIDE CYCLES NUMBER	>>>	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4567
STORAGE SIDE CYCLES NUMBER	>>>	OBJECTIVE: NPV OF SOLAR INVESTMENT	>>>
CAPACITY RATIO (GPM/CMAX)	>>>	HEX COEFFICIENT (BTU/HR F FT**2)	317.05
FLOW PARAMETER Z(CO/P/PRUL)	>>>	TOTAL INSTALLATION COST (\$)	7511.69
FLOW PARAMETER Z1(CO/P/PRUL)	>>>	COLLECTOR FLOW FACTOR(FPP)	0.9468



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* * * * * S O L O A D - 1
* * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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* * * * * DESIGN DATA OPTIONS/INPUTS SUMMARY
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* * * * * >>>> DATA MARCH TO OUTPUT ID NO. 12111
* * * * * 1 MOD-1 LWK AUGUST 1979

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LOCATION	RICHMOND	VA	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		12	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....	37.50		SLOPE:		
MEAN TEMPERATURE.....	57.26		PARAMETER, FRUL....		1.0380
INSOL (BTU/DAY FT*2)	1247.82		INTERCEPT:		
LOAD FACTOR, HDD.....	4071.20		PARAMETER, FRFA....		0.6910
MEAN GROUND TEMP.....	55.00		BASE COST, \$/FT*2....		12.58
					20.00
					0.1150
					0.1050

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY EFFICIENCY	COST	HEATING VALUE	OIL
1	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	

LOAD LOSS	Coefficient (BTU/HR F FT*2)...	Area (F DAY)...	Design Temp. (F)...	Daily DHW Usage (GAL/PER)...	DHW Users (PER)...	Load Effective Press.
1	0.25	5000.00	30000.00	140.00	20.00	6.00
2	0.25	5000.00	30000.00	140.00	20.00	6.00
3	0.25	5000.00	30000.00	140.00	20.00	6.00

HEAT LOAD CHARACTERISTICS

SELECTED PARAMETERS

COLLECTOR	FLUID MEAN TEMPERATURE.....	176.00
COLLECTOR	FLUID DENSITY (LB/FT*3).....	60.81
COLLECTOR	FLUID SPECIFIC HEAT (BTU/LB*F).....	1.0000
COLLECTOR	FLUID CONDUCTIVITY (BTU/HR*FT*F).....	0.3870
STORAGE	FLUID MEAN TEMPERATURE.....	104.00
STORAGE	FLUID DENSITY (LB/FT*3).....	62.09
STORAGE	FLUID SPECIFIC HEAT (BTU/LB*F).....	1.0000
STORAGE	FLUID CONDUCTIVITY (BTU/HR*FT*F).....	0.3640
COLLECTOR	SIDE FLOWING FACTOR (HR F/RTU).....	0.0010
COLLECTOR	SIDE FLOWING FACTOR (HR F/RTU).....	220.00
HEX TUBE	CONDUCTIVITY (BTU/HR*FT*F).....	15.30
ESTIMATED	OPTIMUM STORAGE (LB/AREAC).....	0.20
ESTIMATED	GROUND REFLECTANCE.....	1.0000
ESTIMATED	PUMPING POWER (KWH/AREAC).....	0.93
ESTIMATED	CORRECTION FOR TAU ALPHA PRD.....	10.00
ESTIMATED	INSTALL/LABOR COST (\$/AREAC).....	5.00
ESTIMATED	HEX COST (\$/FT*2).....	0.08
ESTIMATED	STORAGE TANK COST (\$/LB STORED).....	0.01
MAINTENANCE	(% INSTALLED COST/YR).....	



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S C L U A D - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
--RESULTS OF ANALYSIS FOR RICHMOND--VA
>>>>DATA MATCH TO INPUT ID 00. 12111
OMC0-1 LAK AUGUST 1979

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S C L U A D - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
--RESULTS OF ANALYSIS FOR RICHMOND--VA
>>>>DATA MATCH TO INPUT ID NO. 12111
OMC0-1 LAK AUGUST 1979

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S C L U A U - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
--RESULTS OF ANALYSIS FOR RICHMOND--VA
>>>>DATA MATCH TO INPUT ID NO. 12111
OMC0-1 LAK AUGUST 1979

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S C L U A D - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
--RESULTS OF ANALYSIS FOR RICHMOND--VA
>>>>DATA MATCH TO INPUT ID 00. 12111
OMC0-1 LAK AUGUST 1979

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S C L U A U - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
--RESULTS OF ANALYSIS FOR RICHMOND--VA
>>>>DATA MATCH TO INPUT ID NO. 12111
OMCO-1 LAK AUGUST 1979

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S C L U A D - 1
SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
--RESULTS OF ANALYSIS FOR RICHMOND--VA
>>>>DATA MATCH TO INPUT ID NO. 12111
OMCO-1 LAK AUGUST 1979

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S O L O A C - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT TO NC. 12112

IMCD-1 LAK AUGUST 1979

LOCATION	RICHMOND	VA	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....	12		COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....	37.50		SLOPE:		
MEAN TEMPERATURE.....	57.26		PARAMETER, FRUL.....	1.0380	20.00
INSOL (BTU/CAY FT**2)	1247.82		INTERCEPT:		0.1150
LOAD FACTOR, MOD.....	4071.20		PARAMETER, FRFA.....	0.6910	0.1050
MEAN GROUND TEMP.....	55.00		BASE COST, \$/FT**2.....	12.98	

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY BASE	EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	0.90(\$/GAL)	142000.0(BTU/GAL)	
2	ELE	0.99	0.05(\$/KWH)	3413.0(BTU/KWH)	
3	GAS	0.70	1.40(\$/THM)	100000.0(BTU/THM)	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR FT**2)...	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2)...	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY).....	20399.99
DOMESTIC HOT WATER (LFW) DESIGN TEMP.....	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)...	20.00
ESTIMATED DHW USERS (PER).....	0.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS...	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.....	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).....	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE.....	164.00
STORAGE FLUID DENSITY(LB/FT**3).....	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F)...	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/FTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/FTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F).....	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)...	15.30
ESTIMATED GROUND REFLECTANCE.....	0.20
ESTIMATED PUMPING POWER(KWH/ARAC).....	1.0000
ESTIMATED CORRECTION FOR TAIL ALPHA FREQ.	0.53
ESTIMATED INSTALL/LABOR COST (\$/ARAC)...	10.00
ESTIMATED HEX COST (\$/FT**2).....	5.00
ESTIMATED STORAGE TANK COST(\$/LB STORFD)	0.08
MAINTENANCE (& INSTALL CCST/YR).....	0.01



>>>>DATA MATCH TO INPUT ID NC. 12112
MOD-1 LWK AUGUST 1975

>>WEIGHTED AVERAGE
OTHER PARAMETERS



DESIGN DATA OPTIONS/INPLTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NC. 12113
 1400-1 LMX AUGUST 1975

ENERGY COMPARATIVE ESTIMATESSELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY (LB/FT**3).....**F)
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB**F).....**F)
COLLECTOR FLUID CONDUCTIVITY (BTU/HR**FT**F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY (LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT (BTU/LB**F).....
STORAGE FLUID CONDUCTIVITY (BTU/HR**FT**F).....
COLLECTOR SIDE FLOWING FACTOR (HR**F/FTU).....
STORAGE SIDE FLOWING FACTOR (HR**F/FTU).....
HEX TUBE CONDUCTIVITY (BTU/HR**FT**F).....
ESTIMATED OPTIMUM STORAGE (LB/AREA).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER (KW/AREA).....
ESTIMATED CORRECTION FOR TAU ALPHA PRED.....
ESTIMATED INSTALL/LABOR COST ($/AREA).....
ESTIMATED FLEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST ($/LB STCRD).....
ESTIMATED MAINTENANCE ($ INSTALLED COST/YR).....

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176.00
60.81
1.0000
0.3870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
222.00
15.30
0.20
1.0000
0.93
10.00
15.00
0.08
0.01



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>DATA MATCH TC INPUT ID NO. 12113
 MOD-I LWK AUGUST 1975

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEC DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.5	0.5392E C7	0.2637E C7	1419.3	1.577	0.092
FEB	876.0	722.9	39.4	0.7307E C7	0.2582E C7	1849.5	1.355	0.136
MAR	1210.2	572.7	46.6	0.6185E C7	0.2637E C7	2466.7	1.186	0.217
APR	1566.0	455.9	57.7	0.2764E C7	0.2552E C7	3100.2	1.018	0.383
MAY	1762.0	376.3	65.8	0.8240E C6	0.2637E C7	3554.5	0.914	0.565
JUN	1872.4	7.6	73.3	0.8208E C5	0.2552E C7	3749.4	0.873	0.686
JUL	1774.4	0.0	76.9	0.0	0.2637E C7	3660.6	0.852	0.685
AUG	1600.6	0.6	75.5	0.6480E C4	0.2637E C7	3290.7	0.972	0.671
SEP	1347.9	36.4	69.0	0.3931E C6	0.2552E C7	2706.3	1.119	0.583
OCT	1032.7	241.2	58.0	0.2605E C7	0.2637E C7	2047.8	1.335	0.335
NOV	733.0	500.6	48.4	0.5406E C7	0.2552E C7	1521.8	1.556	0.169
DEC	566.8	787.4	39.6	0.3504E C7	0.2637E C7	1251.6	1.646	0.089
TOTAL		4071.2		0.4397E C8	0.3105E C8			0.261

>>>WEIGHTED AVERAGE

OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.990E 03
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR F)	0.652E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFF	1471.1946
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFFICIENT	4486.1680
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)	>>>	COLLECTOR SIDE FLOW RATE (GPM)	2.0302
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>	STORAGE SIDE FLOW RATE (GPM)	138.9749
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0203
HEAT EXCHANGER LENGTH (FT)	>>>	NORMALIZED STORAGE FLOW (GPM/AREAC)	1.3897
HEAT EXCHANGER LENGTH (FT)	>>>	HEAT EXCHANGER EFFECTIVENESS	0.9398
HEX ANNULAR DIAMETER DIFFERENCE (FT)	>>>	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.156E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)	>>>	TOTAL ENERGY DEMAND (BTU/YEAR)	0.750E 08
COLLECTOR SIDE REYNOLDS NUMBER	>>>	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2612
STORAGE SIDE REYNOLDS NUMBER	>>>	OBJECTIVE: NPV OF SOLAR INVESTMENT	0.232E 03
CAPACITY RATIO (CMIN/CMAX)	>>>	HEX COEFFICIENT (BTU/HR F FT**2)	347.60
FLOW PARAMETER Z1(CM/FRUL)	>>>	TOTAL INSTALLATION COST (\$)	3000.24
FLOW PARAMETER Z1(CCP/FRPUL)	>>>	COLLECTOR FLOW FACTOR(FPP)	0.9466

>>>> DATE OUTPUT ID# 12221
MUC-1 IN AUGUST 1979

APPLYC

SLEET, PALMER, S

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR SIDE CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE SIDE FOULING FACTOR(HR F/FTU).....
BLACK TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE.....
ESTIMATED GEOMETRIC REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AF*F/C).....
ESTIMATED CORRECTION FOR TAIL ALPHA FEED.....
ESTIMATED CRYSTALLIZER CDSF (H/ARE*F/C).....
ESTIMATED HEX CDSF (G/G*F**2).....
ESTIMATED STORAGE TANK COST($/L*P*ST*F/C).....
MAIN FAN FAN L OR IN $ C L C C O S T / Y R .....

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[illegible]

- ESTIMATED COEFFICIENCY (RTU/FRUIT F).....
- ESTIMATED OPTIMUM STORAGE (LB/AREC).....
- ESTIMATED PUFFING RESISTANCE.....
- ESTIMATED PUFFING POWER (KW/AFFCC).....
- ESTIMATED CORRECTION FACTOR ALPHA FEED.....
- ESTIMATED COST/LB LABOR COST (\$/AREC).....
- ESTIMATED HEX COST (\$/B32).....
- ESTIMATED STORAGE BANK COST (\$/LB STUFFED).....
- MAINFRAMEL OR INFLATED COST/YR.....

CHILD-1

RESULTS OF ANALYSIS FOR PICHAUD VS.

>>>>DATA MATCH TO INPUT ID NO. 12221
JMC0-1 LOK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AVERAGE TEMPERATURE	HEATING LOAD		BTU/M-SQ-FT	BTU/DAY	FT**2	COLLECTOR TILT FACTOR	STAR ENERGY FACTOR
				LOAD	BTU/HOUR					
JAN	631.5	869.6	36.5	0.2609E	0.3	1.2637E	1419.3	1.640	0.107	
FEB	376.0	722.9	39.4	0.2169E	0.6	0.239E	1849.5	1.427	0.157	
MAR	1210.5	572.7	46.6	0.1171E	0.3	0.2637E	2466.7	1.184	0.254	
APR	1566.0	255.5	57.7	0.7677E	0.7	0.2552E	3100.2	0.969	0.483	
MAY	1732.0	75.5	65.8	0.2289E	0.7	0.2637E	3554.5	0.870	0.791	
JUN	1872.4	7.6	73.3	0.2230E	0.6	0.2552E	3749.4	0.823	0.955	
JUL	1776.4	0.0	76.5	0.0	0.0	0.2637E	3660.6	0.845	0.962	
AUG	1600.6	36.6	75.5	0.1800E	0.5	0.2637E	3250.7	0.826	0.556	
SEP	1597.5	36.4	69.0	0.1092E	0.7	0.3552E	2706.3	1.105	0.865	
OCT	1333.7	241.2	58.0	0.7236E	0.7	0.2637E	2047.8	1.356	0.454	
NOV	733.0	503.6	43.4	0.1502E	0.3	0.2552E	1521.8	1.615	0.211	
DEC	566.8	787.4	39.6	0.2362E	0.6	0.2637E	1291.6	1.720	0.106	
TOTAL		4311.2		0.1221E	0.9	0.3105E	>>>WEIGHTED AVERAGE		0.278	

[illegible]



S I L I D A U - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPLTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 12222
F40D-1 LNK AUGUST 1975

ANALYSIS

ENERGY COMPARATIVE ESTIMATES

INDEX	TYPE	ENERGY BASE	EFFICIENCY	CO ₂	HEATING VALUE	DIL
1	CIL	0.70	0.90 (\$/GAL)	14200	0.0 (BTU/GAL)	
2	ELE	0.99	0.65 (\$/KWH)	3413	0.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/THER)	100000	0.0 (BTU/THER)	

HEAT LOCAL CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR-F-FT**2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DG-F-DAY) ..	20399.99
DOMESTIC HOT WATER (GHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DISLACT (GAL/DF) ..	20.00
ESTIMATED GHW DUCT (P&D) EFFECTIVENESS ..	0.00
ESTIMATED GHP DUCT (P&D) EFFECTIVENESS ..	1.00

SELECTED PARAMETERS

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COLLECTOR FLOW MEAN TEMPERATURE.....
COLLECTOR FLOW DENSITY(LB/FT**3).....
COLLECTOR FLOW SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLOW CONDUCTIVITY(RTU/HR*FT*F).....
STORAGE FLOW MEAN TEMPERATURE.....
STORAGE FLOW DENSITY(LB/FT**3).....
STORAGE FLOW SPECIFIC HEAT(RTU/LB*F).....
STORAGE FLOW CONDUCTIVITY(RTU/HR*FT*F).....
COLLECTOR SIDE FOULING FACTOR(HR*F/BTU)
STORAGE SIDE FOULING FACTOR(HR*F/RTU)
HEX FIBRE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE(LB/ARIAC).....
ESTIMATED GROUND REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/ARIAC).....
ESTIMATED CORRECTION FOR TAU ALPHA PRED.....
ESTIMATED INSTALL/LABOR COST ($/ARIAC).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LB STORED)
ESTIMATED MAINTENANCE (% INSTALLED COST/YR).....

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STUDY APPROACH ----- ECONOMIC ESTIMATES

SYSTEM LIFE(YEARS)...	20.00
DISCOUNT RATE.....	0.0900
INFLATION RATE.....	0.1100

STUDY APPROACH



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 S I L I A D - I
 SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 --- RESULTS OF ANALYSIS FOR RICHMOND --- VA
 * * * * *
 >>>> DATA MATCH FOR INPUT TO HLT 12222
 JMCDD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F		BTU/MONTH	BTU/DAY	BTU/DAY	FT**2		
JAN	631.9	669.6	36.5	0.1774E	03	0.2637E	07	1419.3	1.636	0.126
FEB	876.0	722.9	39.4	0.1475E	08	0.2382E	07	1845.5	1.425	0.184
MAR	1210.2	572.7	46.0	0.1168E	08	0.2637E	07	2466.7	1.185	0.292
APR	1566.0	255.9	57.7	0.5220E	07	0.2552E	07	3100.2	0.991	0.526
MAY	1762.0	76.3	65.8	0.1557E	07	0.2637E	07	3554.9	0.874	0.753
JUN	1872.4	7.6	73.3	0.1550E	06	0.2552E	07	3749.4	0.827	0.932
JUL	1774.4	0.0	76.9	0.0	05	0.2637E	07	3660.6	0.849	0.939
AUG	1600.6	0.6	75.5	0.1224E	05	0.2637E	07	3290.7	0.934	0.934
SEP	1347.9	36.4	69.0	0.7426E	06	0.2552E	07	2706.3	1.107	0.851
OCT	1032.7	241.2	58.0	0.4220E	07	0.2637E	07	2047.8	1.355	0.490
NOV	733.0	500.6	48.4	0.1021E	08	0.2552E	07	1521.8	1.011	0.242
DEC	566.3	787.4	39.6	0.1606E	08	0.2637E	07	1291.6	1.715	0.124
TOTAL		4771.2		0.83305E	08	0.3105E	08		AVERAGE	0.322

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR ARC (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.262E 04
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR F)	0.463E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFF	1142.1814
COLLECTOR SIDE TUBE OUTER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFFICIENT	3769.5509
STORAGE SIDE TUBE (HEX) INNER DIA. (FT)	>>>	COLLECTOR SIDE FLOW RATE (GPM)	5.3729
STORAGE SIDE TUBE FLUID VELOCITY (FT/SEC)	>>>	STORAGE SIDE FLOW RATE (GPM)	52.9791
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	NORMALIZED COLLECTOR FLOW (GPM/AREA)	0.0208
HEAT EXCHANGER LENGTH (FT)	>>>	HEAT EXCHANGER EFFECTIVENESS	0.3605
HEAT EXCHANGER DIAMETER (FT)	>>>	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.8825
HEX ANNUAL LIQUID THERMAL CAPACITY (BTU/HR F)	>>>	TOTAL ENERGY DEMAND (BTU/YEAR)	0.367E 08
COLLECTOR SIDE TUBE DIA. DIFFERENTIAL (FT)	>>>	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.114E 09
COLLECTOR SIDE REYNOLDS NUMBER	>>>	OBJECTIVE: NPV OF SOLAR INVESTMENT	0.259E 04
STORAGE SIDE REYNOLDS NUMBER	>>>	HEX COEFFICIENT (BTU/HR F FT**2)	315.23
CAPACITY (GAL)	>>>	TOTAL INSTALLATION COST (\$)	4674.94
FLOW PARAMETER Z1 (GPM/HR)	>>>	COLLECTOR FLOW FACTOR (FPP)	0.5480
FLOW PARAMETER Z2 (GPM/HR)	>>>		



>>>>DATA MATCH ID OUTPUT ID NC. 12223
IMD-1 LWK AUGUST 1979

LOCATION	RICHMOND	VA	COLLECTOR AMERICAN SUN	STUDY APPROACH	ANALYSIS
COLLECTOR TEST RESULTS,					
SLOPE:					
PARAMETER, FRUL...					
INTERCEPT:					
PARAMETER, FRTA...					
BASE COST, \$/FT**2...					
1.0350					
0.6380					
6.55					
ECONOMIC ESTIMATES					
SYSTEM LIFE(YEARS)...					
DISCOUNT RATE.....					
INFLATION RATE.....					
20.00					
0.0900					
0.1100					

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	PASSE EFFICIENCY	COST	HEATING VALUE	JIL
1	FIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	0.09
2	ELF	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	5000.00
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)	10799.99
					140.00
					20.00
					9.00
					1.00

SELECTED PARAMETERS

COLLECTOR	FLUID MEAN TEMPERATURE.....	176.00
COLLECTOR	FLUID DENSITY(LB/FT**3).....	60.81
COLLECTOR	FLUID SPECIFIC HEAT(BTU/LB*F).....	1.0000
COLLECTOR	FLUID CONDUCTIVITY(BTU/HR*FT*F).....	0.3870
STORAGE	FLUID MEAN TEMPERATURE.....	104.00
STORAGE	FLUID DENSITY(LB/FT**3).....	62.09
STORAGE	FLUID SPECIFIC HEAT(BTU/LB*F).....	1.0000
STORAGE	FLUID CONDUCTIVITY(BTU/HR*FT*F).....	0.3640
COLLECTOR	SIDE FOULING FACTOR(HR F/RTU).....	0.0010
STORAGE	SIDE FOULING FACTOR(HR F/RTU).....	0.0010
HEX TUBE	CONDUCTIVITY(BTU/HR*FT*F).....	226.00
ESTIMATED	OPTIMUM STORACE(LB/AF*EAC).....	15.30
ESTIMATED	GROUND REFLECTANCE.....	0.20
ESTIMATED	PUMPING POWER(KWH/ARE*AC).....	1.0000
ESTIMATED	CORRECTION FOR TAU ALPHA PFC.....	0.93
ESTIMATED	INSTALL/LABOR COST (\$/ARE*AC).....	10.00
ESTIMATED	HEX COST (\$/FT**2).....	5.00
ESTIMATED	STORAGE TANK COST(\$/LF*STPFC).....	0.08
MAINTENANCE	(# INSTALLED COST/YR).....	0.0010



>>>>DATA MATCH TC INPUT ID NO. 12223
 QMOD-1 LWK AUGUST 1975

>>>WEIGHTED AVERAGE

OTHER PARAMETERS

>>>WEIGHTED AVERAGE



DESIGN DATA CAPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NC. 12232
MOD-1 LWK AUGUST 1979

192

SELECTED PARAMETERS

HEAT LOAD CHARACTERISTICS



SL 3A 3-1

RESULTS OF ANALYSIS FOR RICHMOND

TO INPUT ID NO. 12

>>WEIGHTED AVERAGE

OTHER PARAMETERS

THE UNIVERSITY OF CHICAGO



>>>>>DATA MATCH TO OUTPUT ID NO. 13111
IMOD-1 LWK AUGUST 1979

176.00
60.81
1.0000
0.3870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
0.93
10.00
5.00
0.08
0.01



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S O L U D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR MONTEREY CALIF

>>>> DATA MATCH TO INPUT ID NO. 13111

UNCD-1 LWK AUGUST 1979

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MONTH	HORIZONTAL INSULATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE		HEATING LOAD		DHW LOAD		EXTRA-TERRESTRIAL INSULATION		COLLECTOR TILT FACTOR		SOLAR ENERGY FRACTION		
	BTU/DAY	FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH	BTU/DAY	FT**2
JAN	120.0		434.0	51.4	0.1302E	08	0.2637E	C7	1465.7			1.558			0.182		
FEB	930.0		336.0	52.5	0.1008E	08	0.2382E	C7	1852.2			1.383			0.265		
MAR	1410.0		372.0	52.9	0.1110E	08	0.2637E	C7	2500.1			1.155			0.346		
APR	1930.0		333.0	53.5	0.0990E	07	0.2552E	C7	3118.9			1.034			0.442		
MAY	2210.0		282.0	55.9	0.08460E	07	0.2637E	C7	3558.9			0.927			0.515		
JUN	2320.0		201.0	58.3	0.06030E	07	0.2552E	C7	3745.8			0.883			0.612		
JUL	2240.0		174.0	59.4	0.05220E	07	0.2637E	C7	3660.6			0.903			0.659		
AUG	2020.0		136.0	60.6	0.04030E	07	0.2637E	C7	3303.8			0.988			0.723		
SEP	1650.0		84.0	62.2	0.02520E	07	0.2552E	C7	2734.8			1.136			0.796		
OCT	1180.0		136.0	60.6	0.04050E	07	0.2637E	C7	2088.0			1.333			0.575		
NOV	790.0		258.0	56.4	0.07740E	07	0.2552E	C7	1567.5			1.516			0.286		
DEC	620.0		394.0	52.3	0.11820E	08	0.2637E	C7	1338.6			1.602			0.164		
TOTAL			3140.0		0.9420E	08	0.3105E	C8				AVERAGE			0.405		
>>>WEIGHTED AVERAGE																	
OTHER PARAMETERS																	

DESIGN VARIABLES/CONSTRAINTS																	

COLLECTOR AREA (FT**2)				>>>	209.47	COLLECTOR SIDE CAPACITY (BTU/HR F)									0.207E	04	
COLLECTOR TILT ANGLE (DEG)				>>>	31.99	STORAGE SIDE CAPACITY (BTU/HR F)									0.460E	05	
COLLECTOR SIDE TUBE INNER DIA. (FT)				>>>	0.0643	COLLECTOR SIDE CONVECTION COEFF.									1054.0122		
COLLECTOR SIDE TUBE OUTER DIA. (FT)					0.0718	STORAGE SIDE CONVECTION COEFFICIENT									3789.6926		
STORAGE SIDE TUBE(OUTX) INNER DIA. (FT)					0.1352	COLLECTOR SIDE FLOW RATE (GPM)									4.2391		
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)					2.9100	STORAGE SIDE FLOW RATE (GPM)									92.4648		
STORAGE SIDE FLUID VELOCITY (FT/SEC)					19.9917	NORMALIZED COLLECTOR FLOW (GPM/AREA)									0.0202		
HEAT EXCHANGER LENGTH (FT)					37.86	NORMALIZED STORAGE FLOW (GPM/AREA)									0.4414		
HEAT EXCHANGER EFFECTIVENESS						HEAT EXCHANGER EFFECTIVENESS									0.9259		
HEX ANNULAR LIAMETER DIFFERENCE (FT)					0.0634	SOLAR ENERGY DELIVERED (BTU/YEAR)									0.507E	08	
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)					0.0075	TOTAL ENERGY DEMAND (BTU/YEAR)									0.125E	09	
COLLECTOR SIDE REYNOLDS NUMBER					0.477E	ANNUAL AVERAGE SOLAR LOAD FRACTION									0.4046		
STORAGE SIDE REYNOLDS NUMBER					0.179E	OBJECTIVE: NPV OF SOLAR INVESTMENT									0.207E	04	
CAPACITY PATTERN (C/MIN/C MAX)					0.00449	HEX COEFFICIENT (BTU/HR F FT**2)									312.38		
FLOW PARAMETER Z1(CCP/FPOL)					9.5093	TOTAL INSTALLATION COST (\$)									6289.45		
FLOW PARAMETER Z1(GC/FF/FPOL)					9.00	COLLECTOR FLOW FACTOR(FPP)									0.5464		



----- SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN DESIGN DATA OPTIONS/INPUTS SUMMARY -----

>>>>DATA MATCH TO OUTPUT ID NO. 13112
MOD-1 LNK AUGUST 1975

LOCATION	MONTREY	CALIF	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		13	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....		36.60	SLOPE:		
MEAN TEMPERATURE.....		56.40	PARAMETER, FRUL.....		
INSOL (BTU/DAY FT**2)		1505.83	INTERCEPT:		
FACTU, HMD.....		3140.00	PARAMETER, FRTA.....		
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT**2....		
				ECCNOMIC ESTIMATES	
				SYSTEM LIFE(YEARS)...	20.00
				DISCOUNT RATE.....	0.1150
				INFLATION RATE.....	0.1050

SELECTED PARAMETERS

TYPE ENERGY BASE	INDEX	EFFICIENCY	COST	HEATING VALUE	OIL
OIL	1	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	176.00
ELE	2	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	60.81
GAS	3	0.70	0.40 (\$/THER)	100000.0 (BTU/THER)	1.0000

HEAT LOAD CHARACTERISTICS	
LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.17
ECAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	20399.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)	6.00
ESTIMATED STORAGE (PER)	1.00
LOAD EFFECTIVENESS	

COLLECTOR FLUID MEAN TEMPERATURE	176.00
COLLECTOR FLUID DENSITY (LB/FT**3)	60.81
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F) ..	1.0000
COLLECTOR F.L.C CONDUCTIVITY (BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY (LB/FT**3)	62.05
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F) ..	1.0000
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F)	0.3840
COLLECTOR SIDE FOULING FACTOR (HR F/FTU)	0.0010
STORAGE SIDE FOULING FACTOR (HR F/FTU)	0.0010
HEX TUBE CONDUCTIVITY (BTU/HR*FT*F)	220.00
ESTIMATED OPTIMUM REFLECTANCE (LB/AF*AC) ..	15.30
ESTIMATED GROUND REFLECTANCE	0.20
ESTIMATED PUMPING POWER (KWH/AF*AC)	1.0000
ESTIMATED CORRECTION FCR TAU ALPHA FEED ..	0.93
ESTIMATED INSTALL/LABOR COST (\$/AF*AC) ..	10.00
ESTIMATED HEX COST (\$/FT**2)	5.00
ESTIMATED STORAGE TANK COST (\$/LP*STORF)	0.08
MAINTENANCE (\$ INSTALLED COST/YR)	0.01



SOLAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN - RESULTS OF ANALYSIS FOR MONTEREY CALIF

>>>>> DATA MATCH TO INPUT ID NO. 13112
DMCD-1 LAK AUGUST 1979

>>WT LIGHTED AVERAGE

DESIGN VARIABLES/CONSTRAINTS[illegible]



>>>> DATA MATCH TO CUPUR ID NO: 13223
IMOD-1 LMK AUGUST 1979

	176.00
	60.81
	1.0000
	C.397C
	104.00
	62.09
	1.0000
	0.3640
	0.0010
	220.00
	15.3C
	0.20
	1.0000
	0.92
	10.00
	5.00
	C.08
	0.0010



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
RESULTS OF ANALYSIS FOR MONTEREY CALIF.

>>>>DATA MARCH TC INPUT ID NO. 13223
J40D-1 LWK AUGUST 1979

199



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
DESIGN DATA OPTIMUS/SIMULUS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 13232
IMC-D-1 LNA AUGUST 1979

LOCATION	MONTPEY	CALIF	COLLECTOR	FEDERAL PRISON I. D	STUDY APPROACH	ANALYSIS
LOCATION INLEX.....	13		COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATING	
LATITUDE, DEGREES.....	35.60		CLIQUE:			
MEAN TEMPERATURE.....	56.40		PARAMECTER, FRUL....	0.8830		20.00
INSOL (BTU/DAY FT*2).....	1505.83		INTERCEPT:		SYSTEM LIFE (YEARS)...	0.0900
LIQUID FACTOR (HD).....	3140.00		PARAMECTER, FRTA....	0.6270	DISCOUNT RATE.....	0.1100
MEAN GROUND TEMP.....	55.00		BASE COST, \$/FT #2...	9.40	INFLATION RATE.....	

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	PAGE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	0.17
2	ELEC	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	5000.00
3	GAS	0.70	0.40 (\$/THERM)	100000.0 (BTU/THERM)	20399.99
					140.00
					20.00
					6.00
					1.00

HEAT LOAD CHARACTERISTICS	
LOAD LOSS COEFFICIENT (BTU/HR.F.FT**2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG.F.DAY) ..	20399.99
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/DEP)	20.00
ESTIMATED DHW USERS (PEP) ..	6.00
ESTIMATED STAGNANT DHW EFFECTIVE INFLUX ..	1.00

SELECTED PARAMETERS

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FLOWING FACTOR(HR F/RTU).....
STORAGE SIDE FLOWING FACTOR(HR F/RTU).....
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED TYPICAL STORAGE(LB/HR*FAC).....
ESTIMATED GROUND RESISTANCE.....
ESTIMATED PUMPING POWER(KWH/AF*AC).....
ESTIMATED CORRECTION FOR TAIL ALPHABET.....
ESTIMATED INSTALL/LABEL COST ($/AF*AC).....
ESTIMATED HEX COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LF*STOR*F).....
MAINTENANCE & INSTALLED COST/YR.....

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ANALYSIS

SYSTEM LIFE (YEARS) ..	20.00
DISCOUNT RATE	0.0909
INFLATION RATE	0.1100

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR.F (F**2))	0.17
LOAD SURFACE HEAT TRANSFER AREA (F**2)	500.00
LOAD CONDUCTANCE (BTU/DEG.F DAY)	20329.99
DUMP SYSTEM WATER DESIGN TEMP	140.00
ESTIMATED DAILY DHW USAGE (GAL/DEG)	20.00
ESTIMATED DHW USER (PEP)	9.00
ESTIMATED STAGNANT DRAINAGE	1.00

6	176.06
1	60.81
1	1.0000
0	0.3870
1	104.00
5	52.19
1	1.0000
0	0.3640
0	0.0010
0	0.0010
2	220.00
1	15.30
0	0.20
1	1.0000
0	0.93
1	10.00
5	5.00
0	0.08
0	0.010



SOLAR ENERGY FRACTION	
0.345	
0.474	
0.592	
0.717	
0.795	
0.884	
0.921	
0.967	
1.000	
0.833	
0.459	
0.317	
0.637	

100.6

0.279E 04
0.378E 05
1122.7029
3456.71009
5.7146
75.8478
0.0172
0.2360
0.8360
0.606E 08
0.951E 08
0.6370
0.585E 04
315.70
6930.39
0.5464



S O L O A C - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 14111
IMOD-1 LWK AUGUST 1979

LOCATION

COLLECTOR SOLARNETICS

STUDY APPROACH

ANALYSIS

LOCATION INDEX	FRESNO	CALIF	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES	36.77	14	SLOPE:		
MEAN TEMPERATURE	61.85		PARAMETER, FRUL	1.0380	
INSOL (BTU/DAY FT**2)	1710.81		INTERCEPT:		20.00
LOAD FACTOR, FLD	2826.40		PARAMETER, FRIA	0.6910	0.1150
MEAN GROUND TEMP	55.00		BASE COST, \$/FT**2	12.98	0.1050

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASIS	EFFICIENCY	COST	HEATING VALUE	U/L
1	OIL	0.70	0.90 (\$/GAL)	142000.00 (BTU/GAL)		
2	ELC	0.99	0.05 (\$/KWH)	3413.00 (BTU/KWH)		
3	GAS	0.70	0.40 (\$/THERM)	100000.00 (BTU/THERM)		

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)	0.25
LOAD SURFACE HEAT TRANSFER AREA (FT**2)	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)	30000.00
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW USERS (PER)	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE	
COLLECTOR FLUID DENSITY (LB/FT**3)	
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)	
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F)	
STORAGE FLUID MEAN TEMPERATURE	
STORAGE FLUID DENSITY (LB/FT**3)	
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)	
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F)	
COLLECTOR SIDE FOULING FACTOR (HR F/RTU)	
STORAGE SIDE FOULING FACTOR (HR F/RTU)	
HEX TUBE CONDUCTIVITY (BTU/HR FT F)	
ESTIMATED OPTIMUM STORAGE (LB/AREAC)	
ESTIMATED GROUND REFLECTANCE	
ESTIMATED PUMPING POWER (KWH/AREAC)	
ESTIMATED CORRECTION FOR TAU ALPHA PRED.	
ESTIMATED INSTALL/LAFCR CCST (\$/AREAC)	
ESTIMATED HEX COST (\$/FT**2)	
ESTIMATED STORAGE TANK COST (\$/LB STORED)	
MAINTENANCE (% INSTALLED COST/YR)	

176.00
60.81
1.0000
0.3870
104.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
0.53
10.00
5.00
0.08
0.01



* * * * * S O L U A D - 1
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 * * * * * RESULTS OF ANALYSIS FOR FRESNO CALIF
 * * * * * >>>>DATA MATCH TO INPUT ID NO. 14111
 * * * * * UMDC-1 LMK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/DAY FT**2			
JAN	657.0	640.7	44.3	0.1922E 03	0.2637E 07	1456.9	1.571	0.063
FEB	1012.0	442.4	49.3	0.1327E 08	0.2382E 07	1884.2	1.425	0.130
MAR	1566.0	349.7	53.8	0.1049E 08	0.2637E 07	2492.8	1.222	0.241
APR	2093.0	187.0	59.6	0.5010E 07	0.2552E 07	3115.4	1.028	0.409
MAY	2484.0	55.6	67.5	0.1668E 07	0.2637E 07	3558.2	0.901	0.718
JUN	2733.0	5.3	75.3	0.1590E 06	0.2552E 07	3746.5	0.846	0.951
JUL	2685.0	0.0	81.1	0.0	0.2637E 07	3660.6	0.871	0.992
AUG	2423.0	0.3	78.7	0.9000E 04	0.2637E 07	3301.4	0.977	0.995
SEP	1585.0	4.1	73.2	0.1230E 06	0.2552E 07	2729.5	1.165	0.953
OCT	1429.0	105.3	63.2	0.3159E 07	0.2637E 07	2080.5	1.416	0.522
NOV	888.6	394.3	51.9	0.1163E 08	0.2552E 07	1558.9	1.616	0.150
DEC	574.1	641.7	44.3	0.1925E 08	0.2637E 07	1329.8	1.624	0.053
TOTAL		2826.4		0.3479E 08	0.3105E 08			0.256

DESIGN VARIABLES/CONSTRAINTS	OTHER PARAMETERS
COLLECTOR AREA (FT**2) >>>	COLLECTOR SIDE CAPACITY (BTU/HR FT) >>>
COLLECTOR TILT ANGLE (DEG) >>>	STORAGE SIDE CAPACITY (BTU/HR FT) >>>
COLLECTOR SIDE TUBE INNER DIA. (FT) >>>	COLLECTOR SIDE CONVECTION COEFF. >>>
COLLECTOR SIDE TUBE OUTER DIA. (FT) >>>	STORAGE SIDE CONVECTION COEFFICIENT >>>
STORAGE SIDE TUBE (HX) INNER DIA. (FT) >>>	COLLECTOR SIDE FLOW RATE (GPM) >>>
COLLECTOR SIDE FLUID VELOCITY (FT/SEC) >>>	STORAGE SIDE FLOW RATE (GPM) >>>
STORAGE SIDE FLUID VELOCITY (FT/SEC) >>>	NORMALIZED COLLECTOR FLOW (GPM/AREA) >>>
HEAT EXCHANGER LENGTH (FT) >>>	NORMALIZED STORAGE FLOW (GPM/AREA) >>>
HEAT EXCHANGER DIAMETER DIFFERENCE (FT) >>>	HEAT EXCHANGER EFFECTIVE FLOW (GPM/AREA) >>>
HEX ANNUAL DIAMETER DIFFERENCE (FT) >>>	SOLAR ENERGY DELIVERED (BTU/YEAR) >>>
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT) >>>	TOTAL ENERGY DEMAND (BTU/YEAR) >>>
COLLECTOR SIDE RYNOLDS NUMBER >>>	ANNUAL AVERAGE SOLAR LOAD FRACTION >>>
STORAGE SIDE RYNOLDS NUMBER >>>	OBJECTIVE: NPV OF SOLAR INVESTMENT >>>
CAPACITY RATIO (CMIN/CMAX) >>>	HEX COEFFICIENT (BTU/HR FT**2) >>>
FLOW PARAMETER Z1 (GCP/FRUL) >>>	TOTAL INSTALLATION COST (\$) >>>
FLOW PARAMETER Z1 (GCP/FRUL) >>>	COLLECTOR FLOW FACTOR (FPP) >>>



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SCALAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>> DATA MATCH TO OUTPUT IO MC. 14112
IMDD-1 LWK AUGUST 1979

LOCATION	FRESNO	CALIF	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		14			
LATITUDE, DEGREES....		36.77	COLLECTOR TEST RESULTS, SLOPE:	ECONOMIC ESTIMATES	
MEAN TEMPERATURE....		61.85	PARAMETER, FRUL....		
TINSOL (HOURS/DAY FT**2)		1710.81	INTERCEPT:	SYS(TEM LIFE(YEARS))..	20.00
LOAD FACTOR, HDD.....		2826.40	PARAMETER, FRTA....	DISCOUNT RATE	0.1150
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT**2...	INFLATION RATE	0.1050

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.5C (\$/GAL)	142000.0 (BTU/GAL)
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)
3	GAS	0.70	0.40 (\$/THU)	100000.0 (BTU/THU)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR 1 FT**2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	20399.99
DOMESTIC HOT WATER (LFW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	20.00
ESTIMATED CHW USERS (PER) ..	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS ..	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.....	176.00
COLLECTOR FLUID DENSITY (LB/FT**3).....	60.81
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F).....	1.0000
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F).....	0.3870
STORAGE FLUID MEAN TEMPERATURE.....	104.00
STORAGE FLUID DENSITY (LB/FT**3).....	62.09
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F).....	1.0000
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F).....	0.2640
COLLECTOR SIDE FOULING FACTOR (HR F/FTU).....	0.0010
STORAGE SIDE FOULING FACTOR (HR F/FTU).....	0.0010
HEX TUBE CONDUCTIVITY (BTU/HR*FT*F).....	220.00
ESTIMATED OPTIMUM REFLECTANCE (LB/AREAC).....	15.30
ESTIMATED PUMPING POWER (KWH/AREAC).....	0.20
ESTIMATED CORRECTION FOR TAU ALPHA PRED.....	1.0000
ESTIMATED INSTALL/LABOR COST (\$/AREAC).....	0.93
ESTIMATED HEX COST (\$/FT**2).....	10.00
ESTIMATED STORAGE TANK COST (\$/LB STORED).....	5.00
MAINTENANCE (% INSTALLED COST/YR).....	0.00



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN RESULTS OF ANALYSIS FOR FRESNO, CALIF.

>>>>DATA MATCH TO INPUT ID NO. 14112
UNOD-1 LWK AUGUST 1979

205



S O L A R - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>DATA MATCH TO OUTPUT ID NO. 14223
MOD-1 LWK AUGUST 1979

LOCATION	FRSNO	CALIF	COLLECTOR AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		14	COLLECTOR TEST RESULTS,		
LATITUDE, DEGREES.....	36.77		SLOPE:		
MEAN TEMPERATURE.....	61.85		PARAMETER, FRUL.....		1.0390
INSOL (BTU/DAY FT**2)	1710.81		INTERCEPT:		
LOAD FACTOR, HCL.....	2826.40		PARAMETER, FRFA.....		0.6380
MEAN GROUND TEMP.....	55.00		BASE COST, \$/FT**2....		6.55
				SYSTEM LIFE (YEARS)...	20.00
				DISCOUNT RATE.....	0.0900
				INFLATION RATE.....	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY TYPE	BASE EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL	0.70	1.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	FLF	0.59	0.65 (\$/KWH)	3413.0 (BTU/KWH)	
3	GAS	0.70	0.40 (\$/TH)	100000.0 (BTU/TH)	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR FT**2)...	0.09
LOAD SURFACE HEAT TRANSFER AREA (FT**2)...	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)...	1070.99
DOMESTIC HOT WATER (GPH) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW USERS (PER).....	6.00
ESTIMATED STORAGE TANK CAPACITY (GAL).....	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.....	
COLLECTOR FLUID DENSITY (LB/FT**3).....	
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)...	
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F)	
STORAGE FLUID MEAN TEMPERATURE.....	
STORAGE FLUID DENSITY (LB/FT**3).....	
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)...	
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F)...	
COLLECTOR SIDE FLOWING FACTOR (HR F/RTU)	
STORAGE SIDE FLOWING FACTOR (HR F/RTU)	
HEX TUBE CONDUCTIVITY (BTU/HR*FT*F).....	
ESTIMATED OPTIMUM STORAGE (LP/AREAC)	
ESTIMATED GROUND REFLECTANCE.....	
ESTIMATED PUMPING POWER (KWH/AREAC).....	
ESTIMATED CORRECTION FOR TAI ALPHA PEED...	
ESTIMATED INSTALL/LABOR COST (\$/AREAC)...	
ESTIMATED HEX COST (\$/FT**2).....	
ESTIMATED STORAGE TANK COST (\$/LB STIPEO)	
MAINTENANCE (\$ INSTALLED COST/YR).....	

176.00
60.81
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
0.93
10.00
5.00
0.00
0.00



* * * * * S O L A R - 1
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 * * * * * ---
 * * * * * RESULTS OF ANALYSIS FOR FRESNO CALIF
 * * * * *
 * * * * * >>>>DATA MATCH TO INPUT ID NO. 14223
 * * * * * MOD-1 LWK AUGUST 1975

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	DDW LOAD	EXTRA-TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	657.0	640.7	44.3	0.6920E 07	0.2637E 07	1456.5	1.630	0.176	
FEB	1012.0	442.4	49.3	0.4778E 07	0.2382E 07	1384.2	1.458	0.332	
MAR	1566.0	349.7	53.8	0.3777E 07	0.2637E 07	2493.8	1.221	0.536	
APR	2093.0	187.0	59.6	0.2020E 07	0.2552E 07	3115.4	0.956	0.726	
MAY	2484.0	55.6	67.5	0.9005E 06	0.2637E 07	3558.2	0.851	0.911	
JUN	2733.0	5.3	75.3	0.5724E 05	0.2552E 07	3746.5	0.789	1.000	
JUL	2685.0	0.0	81.1	0.0	0.2637E 07	3660.6	0.816	1.000	
AUG	2423.0	0.3	78.7	0.3240E 04	0.2637E 07	3301.4	0.937	1.000	
SEP	1985.0	4.1	73.2	0.4423E 05	0.2552E 07	2729.5	1.153	1.000	
OCT	1429.0	105.3	63.2	0.1137E 07	0.2637E 07	2080.5	1.445	0.825	
NOV	888.6	294.3	51.5	0.4258E 07	0.2552E 07	1558.9	1.679	0.374	
DEC	574.1	841.7	44.2	0.6930E 07	0.2637E 07	1329.8	1.591	0.150	
TOTAL		2826.4		0.3105E 08				AVERAGE	0.509
>>>WEIGHTED AVERAGE									
OTHER PARAMETERS									
COLLECTOR AREA (FT**2)				159.23	COLLECTOR SIDE CAPACITY (BTU/HR)				0.160E 04
COLLECTOR TILT ANGLE (DEG)				43.41	STORAGE SIDE CAPACITY (BTU/HR)				0.288E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)				0.0510	COLLECTOR SIDE CONVECTION COEFF				1301.8782
COLLECTOR SIDE TUBE OUTER DIA. (FT)				0.0575	STORAGE SIDE CONVECTION COEFFICIENT				3251.1172
STORAGE SIDE TUBE (O.D.) INNER DIA. (FT)				0.1161	COLLECTOR SIDE FLOW RATE (GPM)				3.2776
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)				3.5760	STORAGE SIDE FLOW RATE (GPM)				57.8095
STORAGE SIDE FLUID VELOCITY (FT/SEC)				16.1075	NORMALIZED COLLECTOR FLOW (GPM/ARFAC)				0.0200
HEAT EXCHANGER LENGTH (FT)				52.36	NORMALIZED STORAGE FLOW (GPM/APEAC)				0.3630
HEAT EXCHANGER CONSTRAINTS (FT) *****					HEAT EXCHANGER EFFECTIVENESS				0.8114
HEX ANNUAL DIAPHRAGM DIFFERENCE (FT)				0.0536	SOLAR ENERGY DELIVERED (BTU/YEAR)				0.313E 08
COLLECTOR SIDE TUBE DIA. DIFFERENTIAL (FT)				0.0065	TOTAL ENERGY DEMAND (BTU/YEAR)				0.616E 08
COLLECTOR SIDE REYNOLDS NUMBER				0.133E 03	ANNUAL AVERAGE SOLAR LOAD INVESTMENT				0.5091
STORAGE SIDE REYNOLDS NUMBER				0.0095	OBJECTIVE: NPV OF SOLAR INVESTMENT				0.377E 04
CAPACITY RATIO (CMH/CMAX)				9.0628	HEAT COEFFICIENT (BTU/HR F FT**2)				327.35
FLOW PARAMETER Z2 (GPM/FT)				9.15	TOTAL INSTALLATION COST (\$)				2872.10
FLOW PARAMETER Z1 (GPM/FT)					COLLECTOR FLOW FACTOR (FPP)				0.9473



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100-100000-1

SCIENCE AND ENERGY OPTIMIZATION FOR ANALYSIS AND DESIGN

RESULTS OF ANALYSIS FOR FRESEN) CALIF-

>>>>DATA MATCH TO INPUT ID NO. 14232
 >>>>AMAD-1 LNK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT*2	DEG DAY	DEG F				BTU/DAY FT*2		
JAN	651.0	640.7	44.3	0.1307E 08	0.2637E 07	1456.5	1.640	0.142	
FEB	1012.0	442.4	49.3	0.9025E 07	0.2382E 07	1884.2	1.463	0.270	
MAR	1566.0	349.7	53.6	0.7134E 07	0.2637E 07	2453.8	1.219	0.452	
APR	2093.0	187.0	59.6	0.3815E 07	0.2552E 07	3115.4	0.987	0.666	
MAY	2484.0	55.6	67.6	0.1134E 07	0.2637E 07	3558.2	0.839	0.937	
JUN	2733.0	5.3	75.3	0.1081E 06	0.2552E 07	3746.5	0.775	1.000	
JUL	2885.0	0.0	81.1	0.0	0.2637E 07	3600.6	0.803	1.000	
AUG	2423.0	0.5	78.7	0.6120E 04	0.2637E 07	3301.4	0.926	1.000	
SEP	1585.0	4.1	73.2	0.8364E 05	0.2552E 07	2729.5	1.149	1.000	
OCT	1425.0	105.3	63.2	0.2148E 07	0.2637E 07	2080.5	1.449	0.821	
NOV	888.5	394.3	51.9	0.8094E 07	0.2552E 07	1558.9	1.650	0.313	
DEC	574.1	641.7	44.3	0.1303E 08	0.2637E 07	1329.8	1.703	0.122	
TOTAL		2820.4		0.5766E 08	0.3105E 08		>>>WEIGHTED AVERAGE	0.420	

DESIGN VARIABLES/CONSTRAINTS

[illegible]



SCALAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA CAPTIONS/INPUTS SUMMARY

>>>>>EASA MATCH TO CUPJR ID NO. 15111
IMJD-1 LNK AUGUST 1979

LOCATION	TULSA	OKLAHOMA	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		15	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....		36.20	SLOPE:		
MEAN TEMPERATURE.....		59.81	PARAMETER, FRUL....		
INSOL (RTU/DAY FT#2)		1373.47	INTERCEPT:		
LOAD FACTOR, HLD.....		3804.40	PARAMETER, FRIA....	SYSTEM LIFE(YEARS)...	20.00
AVERAGE GROUND TEMP.....		55.00	BASE COST, \$/FT#2...	DISCOUNT RATE	0.1150
				INFLATION RATE	0.1050

ENERGY COMPARATIVE CLIMATES

TYPE INDEX	ENERGY BASE	EFFICIENCY	COST	HEATING VALUE	OIL VALUE
1	OIL	0.70	0.50(\$/GAL)	142000.0(BTU/GAL)	
2	ELE	0.99	0.05(\$/KWH)	3413.0(BTU/KWH)	
3	GAS	0.70	0.40(\$/THM)	100000.0(BTU/THM)	

HEAT LOAD CHARACTERISTICS	
LOAD LOSS COEFFICIENT (BTU/HR F FT**2) ..	0.25
LOAD SURFACE HEAT TRANSFER AREA (FT**2) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY) ..	30000.00
DOMESTIC HOT WATER (DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER) ..	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS:	1.00

COLLECTOR	FLUID	MEAN TEMPERATURE	
COLLECTOR	FLUID DENSITY (LB/FT**3) ..		176.00
COLLECTOR	FLUID SPECIFIC HEAT (BTU/LB*F) ..		60.81
COLLECTOR	FLUID CONDUCTIVITY (BTU/HR*FT*F) ..		1.0000
STORAGE	FLUID MEAN TEMPERATURE ..		0.3870
STORAGE	FLUID DENSITY (LB/FT**3) ..		104.00
STORAGE	FLUID SPECIFIC HEAT (BTU/LB*F) ..		62.09
STORAGE	FLUID CONDUCTIVITY (BTU/HR*FT*F) ..		1.0000
COLLECTOR	SIDE FOULING FACTOR (HR F/BTU) ..		0.3640
STORAGE	SIDE FOULING FACTOR (HR F/BTU) ..		0.0010
HEX TUBE	CONDUCTIVITY (BTU/HR*FT*F) ..		0.0010
ESTIMATED	OPTIMUM STORAGE (LB/AREA) ..		220.00
ESTIMATED	GROUND REFLECTANCE ..		15.30
ESTIMATED	PUMPING POWER (KWH/AREA) ..		0.20
ESTIMATED	CORRECTION FOR TAU ALPHA PRED. ..		1.0000
ESTIMATED	INSTALL/LABOR COST (\$/AREA) ..		0.53
ESTIMATED	HEX COST (\$/FT**2) ..		10.00
ESTIMATED	STORAGE TANK COST (\$/LB STORED) ..		5.00
MAINTENANCE	(% INSTALLED COST/YR) ..		0.08
			0.01



SLDAD-1

ESCALER ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR TULSA OKLAHOMA

>>>>> DATA MATCH TO INPUT ID NC. 15111
JMOD-1 LNK AUGUST 1975

MCMNTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	732.0	906.7	35.8	0.2720E 08	0.2637E C7	1486.3	1.551	0.050
FEB	578.0	681.5	40.9	0.2044E 08	0.2382E C7	1911.1	1.396	0.076
MAR	1306.0	513.7	46.8	0.1541E 08	0.2637E C7	2514.7	1.182	0.120
APR	1603.0	180.3	60.8	0.2409E 07	0.2552E C7	3126.9	1.008	0.282
MAY	1822.0	49.0	68.9	0.1350E 07	0.2637E C7	3560.5	0.905	0.534
JUN	2021.0	1.8	77.0	0.5400E 05	0.2552E C7	3744.0	0.861	0.748
JUL	2031.0	0.3	82.2	0.9000E 04	0.2637E C7	3660.4	0.880	0.781
AUG	1865.0	0.1	80.7	0.3000E 04	0.2637E C7	3309.3	0.966	0.785
SEP	1473.0	21.5	72.7	0.6450E 06	0.2552E 07	2747.3	1.115	0.815
OCT	1164.0	163.0	61.9	0.4890E 07	0.2637E 07	2105.7	1.335	0.292
NOV	827.4	450.8	48.8	0.1472E 08	0.2552E 07	1587.8	1.558	0.100
DEC	659.3	799.9	39.2	0.2400E 08	0.2637E C7	1359.5	1.660	0.051
TOTAL		3804.4		0.11+1E 09	0.3105E C8		AVERAGE	0.160
>>>WEIGHTED AVERAGE<<<								
OTHER PARAMETERS								
COLLECTOR AREA (FT**2)	>>>					CAPACITY (BTU/HR F)	>>>	0.101E 04
COLLECTOR TILT ANGLE (DEG)	>>>					CAPACITY (BTU/HR F)	>>>	0.338E 05
COLLECTOR SLOPE INNER DIA. (FT)	>>>					CONVECTION COEFFICIENT	>>>	875.8582
COLLECTOR SLOPE OUTER DIA. (FT)	>>>					CONVECTION COEFFICIENT	>>>	3562.8655
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)	>>>					FLOW RATE (GPM)	>>>	2.0714
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>					FLOW RATE (GPM)	>>>	67.9400
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>					NORMALIZED COLLECTOR FLOW (GPM/AREAC)	>>>	0.0202
HEAT EXCHANGER LENGTH (FT)	>>>					STORAGE FLOW (GPM/AREAC)	>>>	0.6616
HEAT EXCHANGER DIAMETER DIFFERENCE (FT)	>>>					EFFECTIVENESS	>>>	0.5234
HEX ANNULAR DIAMETER DIFFERENCE (FT)	>>>					SOLAR ENERGY DEMAND (BTU/YEAR)	>>>	0.232E 08
COLLECTOR SIDE TUBE DIA. CLIFF EACH(FT)	>>>					TOTAL ENERGY DEMAND (BTU/YEAR)	>>>	0.145E 09
COLLECTOR SIDE RYNOLDS NUMBER	>>>					ANNUAL AVERAGE SOLAR LOAD INVESTMENT	>>>	0.1600
STORAGE SIDE RYNOLDS NUMBER	>>>					OBJECTIVE: NPV OF SOLAR INVESTMENT	>>>	0.746E 03
CAPACITY RATIO (CMIN/CMAX)	>>>					HEX COEFFICIENT (BTU/HR F FT**2)	>>>	294.31
FLOW PARAMETER Z(COP/FRIEL)	>>>					TOTAL INSTALLATION COST (\$)	>>>	3085.23
FLOW PARAMETER Z(GCP/FRPUL)	>>>					COLLECTOR FLOW FACTOR(FPP)	>>>	0.9463



S U L J A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH TO OUTPUT ID NO. 15112
IM ID-1 LWK AUGUST 1979

LOCATION	TULSA	OKLAHOMA	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		15	COLLECTOR TEST RESULTS,		
LATITUDE DEGREES.....	36.20		SLOPE:		
MEAN TEMPERATURE.....	59.81		PARAMETER, FRUL.....	1.0380	
INSOL(BTU/DAY FT*2)	1373.47		INTERCEPT:		20.00
LOAD FACTOR, HDD.....	3804.40		PARAMETER, FRTA.....	0.6910	0.1150
MEAN GROUND TEMP.....	55.10		BASE COST, \$/FT*2....	12.58	0.1050

ECONOMIC ESTIMATES

SYSTEM LIFE(YEARS)..
DISCOUNT RATE.....
INFLATION RATE.....

ENERGY COMPARATIVE ESTIMATES

TYPE INDEX	ENERGY BASL	EFFICIENCY	COST	HEATING VALUE	OIL
1	CIL	0.70	0.90(\$/GAL)	142000.00(BTU/GAL)	
2	ELF	0.99	0.05(\$/KWH)	3413.00(BTU/KWH)	
3	GAS	0.70	0.40(\$/THERM)	100000.00(BTU/THERM)	

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT*2).. LOAD SURFACE HEAT TRANSFER AREA(FT*2).. LOAD CONDUCTANCE (BTU/DEG F DAY)..... DOMESTIC HOT WATER(DHW) DESIGN TEMP. ESTIMATED DAILY DHW USAGE (GAL/PER) ESTIMATED DHW USERS (PER).....EFFECTIVENESS. ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	0.17 5000.00 20399.59 140.00 20.00 6.00 1.00
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SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE..... COLLECTOR FLUID DENSITY(LB/FT*3)..... COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).. COLLECTOR FLUID CONDUCTIVITY(RTU/HR*FT*F) STORAGE FLUID MEAN TEMPERATURE..... STORAGE FLUID DENSITY(LB/FT*3)..... STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).. STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).. COLLECTOR SIDE FLOWING FACTOR(HR F/BIU) STORAGE SIDE FLOWING FACTOR(HR F/RTU) HEX TUBE CONDUCTIVITY(BTU/HR FT F)..... ESTIMATED OPTIMUM STORAGE(LB/AREAC) ESTIMATED GROUND REFLECTANCE..... ESTIMATED PUMPING POWER(KWH/AREAC)..... ESTIMATED CORRECTION FOR TAU ALPHA PFED.. ESTIMATED INSTALL/LABOR COST (\$/AREAC).. ESTIMATED HEX COST (\$/FT*2)..... ESTIMATED STORAGE TANK COST(\$/LP STORED) MAINTENANCE (% INSTALLED COST/YR).....	176.00 60.81 1.0000 0.3870 104.00 62.09 1.0000 0.3640 0.0010 0.0010 220.00 15.30 0.20 1.0000 0.93 10.00 5.00 0.08 0.01
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* * * * * S O L O A D - 1
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 * * * * * RESULTS OF ANALYSIS FOR TULSA OKLAHOMA
 * * * * * >>>> DATA MATCH TO INPUT ID NO. 15112
 * * * * * JMOD-1 LMK AUGUST 1975

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	RTU/MONTH	DHW LOAD	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	RTU/CAY FT**2	DEG DAY	DEG F	RTU/MONTH	RTU/MONTH	RTU/MONTH	RTU/DAY FT**2		
JAN	732.0	906.7	35.8	0.1850E 08	0.2637E 07	0.2637E 07	1486.3	1.600	0.069
FEB	978.0	681.3	40.9	0.1390E 08	0.2382E 07	0.2382E 07	1911.1	1.401	0.103
MAR	1306.0	513.7	48.8	0.1048E 08	0.2637E 07	0.2637E 07	2514.7	1.182	0.166
APR	1603.0	180.3	60.8	0.3678E 07	0.2552E 07	0.2552E 07	3126.9	1.005	0.341
MAY	1822.0	45.0	68.9	0.9180E 06	0.2637E 07	0.2637E 07	3560.5	0.900	0.568
JUN	2021.0	1.8	77.0	0.3672E 05	0.2552E 07	0.2552E 07	3744.0	0.855	0.735
JUL	2031.0	0.3	82.2	0.6120E 04	0.2637E 07	0.2637E 07	3660.4	0.874	0.766
AUG	1865.0	0.1	80.7	0.2040E 04	0.2637E 07	0.2637E 07	3309.3	0.962	0.771
SEP	1473.0	21.5	72.7	0.4386E 06	0.2552E 07	0.2552E 07	2747.3	1.114	0.632
OCT	1164.0	163.0	61.9	0.3325E 07	0.2637E 07	0.2637E 07	2105.7	1.342	0.352
NOV	827.4	490.8	48.8	0.1001E 03	0.2552E 07	0.2552E 07	1587.8	1.566	0.133
DEC	659.5	799.9	39.2	0.1632E 08	0.2637E 07	0.2637E 07	1359.5	1.670	0.070
TOTAL		3804.4		0.7761E 08	0.3105E 08	0.3105E 08		AVERAGE	0.206

>>>WEIGHTED
 OTHER PARAMETERS

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.987E 03
COLLECTOR TILT ANGLE (DEG)	>>>	COLLECTOR SIDE CONVECTION COEFF (BTU/HR F)	0.360E 05
COLLECTOR TUBE INNER DIA. (FT)	>>>	STORAGE SIDE CONVECTION COEFF	989.6692
COLLECTOR TUBE OUTER DIA. (FT)	>>>	COLLECTOR SIDE FLOW RATE (GPM)	3577.6553
STORAGE SIDE TUBE(HELX) INNER DIA. (FT)	>>>	NORMALIZED STORAGE FLOW (GPM/AREAC)	2.0237
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)	>>>	HEAT EXCHANGER EFFECTIVENESS	12.3214
STORAGE SIDE FLUID VELOCITY (FT/SEC)	>>>	SOLAR ENERGY DELIVERED (BTU/YEAR)	0.0202
HEAT EXCHANGER LENGTH (FT)	>>>	TOTAL ENERGY DEMAND (BTU/YEAR)	0.7232
HEAT EXCHANGER DIAMETER (FT)	>>>	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.9380
HEX ANNULAR DIAMETER DIFFERENCE (FT)	>>>	HEX COEFFICIENT (BTU/HR F FT**2)	0.224E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	>>>	COLLECTOR FLOW FACTOR	0.109E 09
COLLECTOR SIDE REYNOLDS NUMBER	>>>	TOTAL INSTALLATION COST (\$)	0.2002
STORAGE SIDE REYNOLDS NUMBER	>>>	COLLECTOR FLOW FACTOR	0.690E 03
CAPACITY RATIO (CAP/CMAX)	>>>	COLLECTOR FLOW FACTOR	306.53
FLOW PARAMETER Z2(CCP/FRUL)	>>>	COLLECTOR FLOW FACTOR	3006.56
FLOW PARAMETER Z1(CCP/FRUL)	>>>	COLLECTOR FLOW FACTOR	0.9464



20.00
C.0900
C.1100

176.00	1.0000	15.30	1.0000	0.0010
60.81	0.2740	0.20	0.53	
1.0000	0.0010	0.00	10.00	
0.3870	0.0010	5.00	0.08	
104.00	0.0010	220.00	0.0010	
62.09				

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COLLECTOR FLUID MEAN TEMPERATURE .....
COLLECTOR FLUID DENSITY (LB/FT**3) .....
COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F) .....
COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F) .....
STORAGE FLUID MEAN TEMPERATURE .....
STORAGE FLUID DENSITY (LB/FT**3) .....
STORAGE FLUID SPECIFIC HEAT (BTU/LB*F) .....
STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F) .....
COLLECTOR SIDE FLOWING FACTOR (HR F/RTU) .....
STORAGE SIDE FLOWING FACTOR (HR F/RTU) .....
HEX TUBE CONDUCTIVITY (BTU/HR*FT*F) .....
ESTIMATED OPTIMUM STORAGE (LB/AREAC) .....
ESTIMATED GROUND REFLECTANCE .....
ESTIMATED PUMPING POWER (KW/AREAC) .....
ESTIMATED CORRECTION FOR TAU ALPHA PPED .....
ESTIMATED INSTALL/LABER COST (4/AREAC) .....
ESTIMATED HUX COST ($/FT**2) .....
ESTIMATED STORAGE TANK COST (4/LB STOPED) .....
MAINTENANCE ($ INSTALLED COST/YR) .....

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LCAD	LCSS	Coefficient	(BTU/Hr Ft**2)	..	0.09
LCAD	SURFACE	HEAT TRANSFER AREA	(Ft**2)	..	500.00
LCAD	CONDUCTANCE	(BTU/DEG F DAY)	..	..	10799.99
LCDOMESTIC	HOT WATER	(Lbm)	DESIGN TEMP	..	120.00
ESTIMATED	DAILY FLOW	USAGE	(GAL/PER)	..	20.00
ESTIMATED	DEMAND	PEAK	..	..	6.00
ESTIMATED	STORAGE	..	..	..	1.00
		LCAD EFFECTIVENESS	..	..	..



* * * * * S I L J A D - I * * * * *
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN * * * * *
 * * * * * --- RESULTS OF ANALYSIS FOR TULSA OKLAHOMA * * * * *
 * * * * * >>>> DATA MATCH TO INPUT ID NO. 15223 * * * * *
 * * * * * JPCD-1 LWK AUGUST 1979 * * * * *

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	DHW LOAD	BTU/MONTH	EXTRA- TERRRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH				BTU/DAY FT**2		
JAN	732.0	506.7	35.8	0.5792E 07	0.2637E 07			1486.3	1.639	0.210
FEB	978.0	681.3	40.5	0.7358E 07	0.2582E 07			1511.1	1.420	0.293
MAR	1206.0	513.7	48.8	0.5543E 07	0.2637E 07			2514.7	1.179	0.434
APR	1603.0	180.3	60.8	0.1947E 07	0.2552E 07			3126.9	0.986	0.683
MAY	1822.0	45.0	68.9	0.4860E 06	0.2637E 07			3560.5	0.872	0.854
JUN	2021.0	1.8	77.0	0.1944E 06	0.2552E 07			3744.0	0.823	0.945
JUL	2031.0	0.5	82.2	0.3240E 06	0.2637E 07			3660.4	0.844	0.974
AUG	1865.0	1.1	80.7	0.1080E 06	0.2637E 07			3309.3	0.935	0.982
SEP	1473.0	21.5	72.7	0.2322E 06	0.2552E 07			2747.3	1.105	0.902
OCT	1164.0	163.0	61.5	0.1760E 07	0.2637E 07			2105.7	1.356	0.705
NOV	827.4	490.8	48.8	0.5301E 07	0.2552E 07			1587.8	1.602	0.363
DEC	659.3	755.9	39.2	0.8639E 07	0.2637E 07			1359.5	1.716	0.212
TOTAL		3304.4		0.4109E 08	0.3105E 08					
			DESIGN VARIABLES/CONSTRAINTS					>>>WEIGHTED AVERAGE		0.461
			OTHER PARAMETERS							

DESIGN VARIABLES/CONSTRAINTS									
>>>WEIGHTED AVERAGE OTHER PARAMETERS<<<<									
COLLECTOR AREA (FT**2)	211.75	COLLECTOR SIDE CAPACITY (BTU/HR F)	...	...	...	...	...	...	0.219E 04
COLLECTOR TILT ANGLE (DEG)	41.00	STORAGE SIDE CAPACITY (BTU/HR F)	...	...	...	...	...	...	0.392E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0657	COLLECTOR SIDE CONVECTION COEFF. (BTU/HR F)	...	...	...	...	...	...	1.660E 04
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0717	STORAGE SIDE CONVECTION COEFFICIENT	...	...	...	...	...	...	3584.2903
STORAGE SIDE TUBE(HEX) INLET DIA. (FT)	0.1312	COLLECTOR SIDE FLOW RATE (GPM)	...	...	...	...	...	...	4.4805
STORAGE SIDE FLUID VELOCITY (FT/SEC)	2.9484	STORAGE SIDE FLOW RATE (GPM)	...	...	...	...	...	...	18.6355
STORAGE SIDE FLUID VELOCITY (FT/SEC)	18.4803	NORMALIZED COLLECTOR FLOW (GPM/AREA)	...	...	...	...	...	...	0.0212
HEAT EXCHANGER LENGTH (FT)	77.37	NORMALIZED STORAGE FLOW (GPM/AREA)	...	...	...	...	...	...	0.3714
HEAT EXCHANGER DIAMETER (FT)	0.0595	HEAT EXCHANGER EFFECTIVENESS	...	...	...	...	...	...	0.8905
HEX ANNUAL CAPACITY DIFFERENCE (FT)	0.0360	SOLAR ENERGY DELIVERED (BTU/YEAR)	...	...	...	...	...	...	0.332E 03
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT)	0.494E 02	TOTAL ENERGY DEMAND (BTU/YEAR)	...	...	...	...	...	...	0.721E 03
COLLECTOR SIDE REYNOLDS NUMBER	0.155E 06	ANNUAL AVERAGE SOLAR LOAD FRACTION	...	...	...	...	...	...	0.4608
STORAGE SIDE REYNOLDS NUMBER	0.0553	SUBJECTIVE: NPV OF SOLAR INVESTMENT	...	...	...	...	...	...	0.313E 04
CAPACITY RATIO (CMH/CMAX)	9.9329	HEX COEFFICIENT (BTU/HR F FT**2)	...	...	...	...	...	...	311.38
FLOW PARAMETER Z2 (GPM/FT**2)	9.9329	TOTAL INSTALLATION COST (\$)	...	...	...	...	...	...	3844.03
FLOW PARAMETER Z1 (GCF/HRPUL)	9.9329	COLLECTOR FLOW FACTOR(FPP)	...	...	...	...	...	...	0.9488



>>>>DATE MATCH T1 OUTPUT ID 40. 15232
INCD-1 LNK AUGUST 1979

SELECTED PARAMETERS

TYPE ENERGY BASE	EFFICIENCY	COST	HEATING VALUE	HEAT
INDEX	TYPE			
1	OIL	0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)
2	ELE	0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)
3	GAS	0.70	0.40 (\$/THM)	100000.0 (BTU/THM)

HEAT LOAD CHARACTERISTICS	
LOAD LOSS COEFFICIENT (BTU/Hr I FT**2)	0.17
LOAD SURFACE HEAT TRANSFER AREA (FT**2)	9000.00
LOAD CONDUCTANCE (BTU/DIG F HRY)	26399.99
DOMESTIC HOT WATER (LHM) DESIGN TEMP.	140.00
ESTIMATED DAILY GAS USAGE (GAL/PLR)	20.00
ESTIMATED DFM USEPS (CFR)	6.00
ESTIMATED STURKES T LOAD EFFECTIVENESS	1.00



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**          **          **          **          **          **          **          **
**      COLAD - 1                                         **          **          **
**          **          **          **          **          **          **          **
**      SOLAP ENERGY OPTIMIZATION ANALYSIS TC DESIGN    **          **          **
**      -----RESULTS OF ANALYSIS FOR TULSA OKLAHOMA----- **          **          **
**          **          **          **          **          **          **          **
**      >>>>DATA WATCH TO INPUT ID NO. 16232           **          **          **
**          **          **          **          **          **          **          **
**          **          **          **          **          **          **          **

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MONTH	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FACTOR
	DEG DAY	DEG F				BTU/DAY FT**2		
JAN	732.0	35.8	0.1850E 08	0.2637E 07	1486.3		1.649	0.146
FEB	976.0	40.5	0.1390E 08	0.2382E 07	1911.1		1.429	0.208
MAR	1306.0	48.8	0.1048E 08	0.2637E 07	2514.7		1.176	0.315
APR	1603.0	60.8	0.3673E 07	0.2552E 07	3126.9		0.973	0.581
MAY	1822.0	68.9	0.9180E 06	0.2637E 07	3560.5		0.853	0.842
JUN	2021.0	77.0	0.3672E 05	0.2552E 07	3744.0		0.802	0.578
JUL	2031.0	82.2	0.6120E 04	0.2637E 07	3660.4		0.824	1.000
AUG	1865.0	80.7	0.2040E 04	0.2637E 07	3309.3		0.923	1.000
SEP	1473.0	72.7	0.4385E 06	0.2552E 07	2747.3		1.057	0.925
OCT	1104.0	61.5	0.3325E 07	0.2637E 07	2105.7		1.361	0.625
NOV	827.4	48.8	0.1301E 08	0.2552E 07	1587.8		1.620	0.269
DEC	659.3	39.2	0.1532E 08	0.2637E 07	1359.5		1.740	0.150
TOTAL			0.7761E 08	0.3105E 08				
DESIGN VARIABLES/CONSTRAINTS							>>>WEIGHTED AVERAGE OTHER PARAMETERS	0.347

COLLECTOR AREA (FT**2)	TILT ANGLE (DEG)	TUBE INNER DIA. (FT)	TUBE OUTER DIA. (FT)	ICE TUB(H)X) INJER DIA. (FT)	COLLECTOR SIDE FLOW VELOCITY (FT/SEC)	COLLECTOR SIDE FLOW VELOCITY (FT/SEC)	HEAT EXCHANGER LENGTH (FT)	CONSTRAINTS(//////////)	HEX ANNUAL DIAMETER (FT)	COLLECTOR SIDE TUBE DIA. DIFFER FIC(FT)	COLLECTOR SIDE FLOW VELOCITY (FT/SEC)	COLLECTOR SIDE FLOW VELOCITY (FT/SEC)	CAPACITY RATIO (CMIN/CMAX)	FLOW PARAMETER Z(CP/FTUL)	FLOW PARAMETER Z(CP/FTUL)
222.35	43.64	0.0563	0.0618	0.1208	3.4420	17.1980	86.71	0.0591	0.0050	0.0050	0.145E 06	0.0586	9.7116	9.20	
COLLECTOR SIDE CAPACITY (BTU/HR F)	STORAGE SIDE CAPACITY (BTU/HR F)	COLLECTOR SIDE CONVECTION COEFF.	STORAGE SIDE CONVECTION COEFF.	COLLECTOR SIDE FLOW RATE (GPM)	STORAGE SIDE FLOW RATE (GPM)	NORMALIZED COLLECTOR FLOW (GPM/AFEA(C))	HEAT EXCHANGER EFFECTIVENESS	SOLAR ENERGY DELIVERED (BTU/YEAR)	TOTAL ENERGY DEMAND (BTU/YEAR)	ANNUAL AVERAGE SOLAR LOAD FRACTION	OBJECTIVE: NPV OF SOLAR INVESTMENT	HEX COEFFICIENT (BTU/HR F FT**2)	TOTAL INSTALLATION COST (\$)	COLLECTOR FLOW FACTOR(FPP)	
0.151E 09	0.326E 05	1935.9021	3411.1858	5.9093	65.3802	0.0176	0.2940	0.8581	0.377E 03	0.109E 09	0.3473	0.329E 04	323.69	4645.24	0.9476



SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
 DESIGN DATA OPTIONS/INPUTS SUMMARY
 >>>> DATA MATCH TO OUTPUT ID NO. 16111
 IMCD-1 LWK AUGUST 1979

LOCATION	NORFOLK VIRGINIA	COLLECTOR SOLARNETICS	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....	16	COLLECTOR TEST RESULTS,	ECONOMIC ESTIMATES	
LATITUDE, DEGREES.....	36.90	SLOPE:		
MEAN TEMPERATURE.....	59.22	PARAMETER, FT*2.....		
INSOL (BTU/DAY FT*2)	1325.29	INTERCEPT:	SYSTEM LIFE (YEARS)...	20.00
LOAD FACTOR, HDD.....	3510.50	PARAMETER, FT*2.....	DISCOUNT RATE.....	0.1150
MEAN GROUND TEMP.....	55.00	BASE COST, \$/FT*2....	INFLATION RATE.....	0.1050

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE.....	OIL	COLLECTOR FLUID MEAN TEMPERATURE.....	176.00
INDEX TYPE EFFICIENCY.....	COST	COLLECTOR FLUID DENSITY (LB/FT*3).....	60.81
1 OIL	0.70	COLLECTOR FLUID SPECIFIC HEAT (BTU/LB*F)...	1.0000
2 ELE	0.99	COLLECTOR FLUID CONDUCTIVITY (BTU/HR*FT*F)	0.3870
3 GAS	0.70	STORAGE FLUID MEAN TEMPERATURE.....	104.00
		STORAGE FLUID DENSITY (LB/FT*3).....	62.09
		STORAGE FLUID SPECIFIC HEAT (BTU/LB*F)...	1.0000
		STORAGE FLUID CONDUCTIVITY (BTU/HR*FT*F)	0.3640
		COLLECTOR SIDE FOULING FACTOR (HR*F/8TU)	0.0010
		STORAGE SIDE FOULING FACTOR (HR*F/8TU)	0.0010
		HEX TUBE CONDUCTIVITY (BTU/HR*FT*F).....	220.00
		ESTIMATED OPTIMUM STORAGE (LB/AREAC).....	15.30
		ESTIMATED GROUND REFLECTANCE.....	0.20
		ESTIMATED PUMPING POWER (KWH/AREAC).....	1.0000
		ESTIMATED CORRECTION FOR TAU ALPHA PRFD..	0.93
		ESTIMATED INSTALL/LABCF COST (\$/AREAC)...	10.00
		ESTIMATED HEX COST (\$/F T*2).....	5.00
		ESTIMATED STORAGE TANK COST (\$/LB STOPED)	0.08
		MAINTENANCE (% INSTALLED COST/YR).....	0.01

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR*F FT*2)...	0.25
LOAD SURFACE HEAT TRANSFER AREA (FT*2)...	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY).....	5000.00
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER)	20.00
ESTIMATED DHW USERS (PER).....	6.00
ESTIMATED STORAGE TANK LOAD EFFECTIVENESS.	1.00



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SOLAR ENERGY OPTIMIZATION ANALYSIS FOR DESIGN
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RESULTS OF ANALYSIS FOR NCRFCLK VIRGINIA

>>>>DATA MATCH TO INPUT ID NC. 16111
JMM00-1 LWK AUGUST 1975

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MONTH	HORIZONTAL INSOLATION		HEATING DEGREE DAYS		AMBIENT TEMPERATURE		HEATING LOAD		DHW LOAD		EXTRA-TERRESTRIAL INSOLATION		COLLECTOR TILT FACTOR		SOLAR ENERGY FRACTION	
	BTU/DAY	FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH	BTU/DAY	FT**2	BTU/MONTH
JAN	679.6		164.4	40.3	0.2293E 08		0.2637E 07	1450.2		0.2637E 07		1.588		0.051		
FEB	931.4		655.4	41.8	0.1966E 08		0.2382E 07	1878.0		0.2382E 07		1.400		0.072		
MAR	1281.0		527.5	48.1	0.1583E 08		0.2637E 07	2489.0		0.2637E 07		1.188		0.118		
APR	1676.7		248.0	57.9	0.7440E 07		0.2552E 07	3112.7		0.2552E 07		1.016		0.239		
MAY	1887.5		71.7	66.2	0.2151E 07		0.2637E 07	3557.7		0.2637E 07		0.909		0.472		
JUN	2000.5		4.9	74.1	0.1470E 06		0.2552E 07	3747.1		0.2552E 07		0.865		0.713		
JUL	1853.2		0.0	77.7	0.0		0.2637E 07	3660.7		0.2637E 07		0.886		0.710		
AUG	1680.2		0.1	76.7	0.3000E 04		0.2637E 07	3299.5		0.2637E 07		0.968		0.702		
SEP	1395.6		10.1	71.5	0.3030E 06		0.2552E 07	2725.4		0.2552E 07		1.116		0.619		
OCT	1083.0		153.5	61.2	0.4005E 07		0.2637E 07	2074.7		0.2637E 07		1.335		0.271		
NOV	811.2		403.0	51.8	0.1209E 08		0.2552E 07	1552.3		0.2552E 07		1.578		0.114		
DEC	623.8		671.9	43.3	0.2016E 08		0.2637E 07	1323.0		0.2637E 07		1.668		0.055		
TOTAL			3510.5		0.1053E 09		0.3105E 08									
		DESIGN VARIABLES/CONSTRAINTS										>>>WEIGHTED AVERAGE				0.161
												OTHER PARAMETERS				

COLLECTOR AREA	(FT*2)	100.00	COLLECTOR SIDE CAPACITY (BTU/HR F)	0.991E 03
COLLECTOR TILT	ANGLE (DEG)	35.79	STORAGE SIDE CAPACITY (BTU/HR F)	C.447E 05
COLLECTOR SIDE	TUBE INNER DIA. (FT)	0.0426	COLLECTOR SIDE CONVECTION COEFF.	1226.7756
COLLECTOR SIDE	TUBE OUTER DIA. (FT)	0.0526	STORAGE SIDE CONVECTION COEFFICIENT	3832.4253
STORAGE SIDE	TUBE(THX) INNER DIA. (FT)	0.1246	COLLECTOR SIDE FLOW RATE (GPM)	2.0309
COLLECTOR SIDE	FLUID VELOCITY (FT/SEC)	3.1742	STORAGE SIDE FLOW RATE (GPM)	89.6943
STORAGE SIDE	FLUID VELOCITY (FT/SEC)	19.9255	NORMALIZED COLLECTOR FLOW (GPM/AREAC)	0.0203
HEAT EXCHANGER	LENGTH (FT)	65.36	NORMALIZED STORAGE FLOW (GPM/AREAC)	0.8565
HEAT EXCHANGER	CONSTRAINTS(//////////)		HEAT EXCHANGER EFFECTIVENESS	0.9424
HEX ANNUAL DIAMETER DIFFERENCE(FT)		0.0720	SOLAR ENERGY DELIVERED (BTU/YEAR)	C.220E C8
COLLECTOR SIDE	TUBE DIA. DIFFERENCE(FT)	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.136E 09
COLLECTOR SIDE	REYNOLDS NUMBER	0.345E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1614
STORAGE SIDE	REYNOLDS NUMBER	0.203E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT	0.626E 03
CAPACITY RATIO	(CATH/LMAX)	0.0222	HEX COEFFICIENT (BTU/HR F FT*2)	328.02
FLOW PARAMETER	Z2(CLP/FRUL)	9.5433	TOTAL INSTALLATION COST (\$)	3004.16
FLOW PARAMETER	Z1(CCP/FRPUL)	9.93	COLLECTOR FLOW FACTOR(FPP)	0.5466



>>>>DATA MATCH TO OUTPUT ID NC: 16112
IMD-1 LWK AUGUST 1975

176.00	60.81	1.0000	0.2870	1104.00	62.09	1.0000	0.3640	00.0010	00.0010	220.00	15.30	0.20	1.0000	0.92	10.00	5.00	0.08	0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA

>>>>DATA MATCH TO INPUT ID NO. 16112
JMOD-1 LWK AUGUST 1975

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/DAY	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2			
JAN	679.0	764.4	40.3	0.1559E 08	0.2637E C7	1450.2	1.582	0.071	
FEB	531.4	655.4	41.8	0.1337E 08	0.2382E C7	1878.0	1.357	0.099	
MAR	1281.0	527.5	48.1	0.1076E 08	0.2637E C7	2489.0	1.188	0.160	
APR	1676.7	248.0	57.9	0.5059E 07	0.2552E C7	3112.7	1.018	0.305	
MAY	1887.5	71.7	66.2	0.1463E 07	0.2637E C7	3557.7	0.912	0.525	
JUN	2000.3	4.9	74.1	0.5996E 05	0.2552E C7	3747.1	0.869	0.724	
JUL	1853.2	0.0	77.7	0.0	0.2637E C7	3660.7	0.889	0.713	
AUG	1680.2	0.1	76.7	0.2346E 04	0.2637E C7	3299.5	0.971	0.704	
SEP	1395.0	10.1	71.5	0.2060E 06	0.2552E C7	2725.4	1.117	0.634	
OCT	1083.0	153.5	61.2	0.3131E 07	0.2637E C7	2074.7	1.333	0.329	
NOV	811.2	403.0	51.8	0.8221E 07	0.2552E C7	1552.3	1.572	0.152	
DEC	623.8	671.9	43.3	0.1371E 08	0.2637E C7	1323.0	1.661	0.075	
TOTAL		3510.5		0.7161E 03	0.3105E C8			0.211	

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2)	>>>	COLLECTOR SIDE CAPACITY (BTU/HR F)	
COLLECTOR TILT ANGLE (DEG)	>>>	STORAGE SIDE CAPACITY (BTU/HR F)	0.987E 03
COLLECTOR TUBE INNER DIA. (FT)	>>>	COLLECTOR SIDE CONVECTION COEFF.	0.575E 05
COLLECTOR TUBE OUTER DIA. (FT)		STORAGE SIDE CONVECTION COEFFICIENT	1120.8818
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)		COLLECTOR SIDE FLOW RATE (GPM)	4014.7375
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)		STORAGE SIDE FLOW RATE (GPM)	2.0237
STORAGE SIDE FLUID VELOCITY (FT/SEC)		NORMALIZED COLLECTOR FLOW (GPM/AREA)	115.4498
HEAT EXCHANGER LENGTH (FT)		NORMALIZED STORAGE FLOW (GPM/AREA)	0.0202
HEAT EXCHANGER DIAMETER (FT)		HEAT EXCHANGER EFFECTIVENESS	1.1545
HEX ANNUAL DIAMETER DIFFERENCE (FT)		SOLAR ENERGY DELIVERED (BTU/YEAR)	0.9498
COLLECTOR SIDE TUBE CL. DIFFERENCE (FT)		TOTAL ENERGY DEMAND (BTU/YEAR)	0.217E 08
COLLECTOR SIDE REYNOLDS NUMBER		ANNUAL AVERAGE SOLAR LOAD FRACTION	0.103E 09
STORAGE SIDE REYNOLDS NUMBER		SUBJECTIVE: NPV OF SOLAR INVESTMENT	0.2111
CAPACITY RATIO (GPM/CHX)		HEX COEFFICIENT (BTU/HR F FT**2)	0.569E 03
FLOW PARAMETER 22(GCP/FRUL)		TOTAL INSTALLATION COST (\$)	3007.50
FLOW PARAMETER 21(GCP/FRPU)		COLLECTOR FLOW FACTOR(FPP)	0.9464

>>>WEIGHTED AVERAGE
OTHER PARAMETERS



DESIGN DATA OPTIMIZATION ANALYSIS OR DESIGN SUMMARY

>>>>> DAT 4 MATCH T1 QUPUR ID 411: 10222
IMCD-1 LWK AUGUST 1979

LOCATION	NORFOLK VIRGINIA	COLLECTOR	AMERICAN SUN	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....	10	COLLECTOR TEST RESULTS,			
LATITUDE, DEGREES.....	36.90	SLOPE:			
MEAN TEMPERATURE.....	59.22	PARAMETER, FRUL.....	1.0390		
INSOL (BTU/CLAY FT*2)	1325.29	INTERCEPT:			
LOAD FACTOR, HOD.....	3510.50	PARAMETER, FTA.....	0.6380	SYSTEM LIFE (YEARS)...	20.00
MEAN GROUND TEMPERATURE.....	55.00	BASE COST, L/FT*2...		DISCOUNT RATE	0.0900
				INFLATION RATE	0.1100

SELECTED PARAMETERS

TYPE INDEX	ENERGY TYPE	BASIS	EFFICIENCY	COST	HEATING VALUE	OIL
1	OIL		0.70	0.90 (\$/GAL)	142000.0 (BTU/GAL)	
2	ELECT		0.99	0.05 (\$/KWH)	3413.0 (BTU/KWH)	
3	COAL		0.70	0.40 (\$/TUM)	100000.0 (BTU/TUM)	

HEAR LIND CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR-F-°F*2) ..	0.17
LOAD SURFACE HEAT TRANSFER AREA (F*°F) ..	5000.00
LOAD CONDUCTANCE (BTU/DEG-F-DAY) ..	20399.99
DOMESTIC HOT WATER (GAL) DEDUCTN TEMP. ..	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ..	50.00
ESTIMATED UTILITIES (PER) ..	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS ..	1.00

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COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LR*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LR*F).....
STORAGE FLUID CONDUCTIVITY(BTU/FT*F).....
COLLECTOR SIDE FLOWING FACTOR(HR F/RTU).....
STORAGE SIDE FLOWING FACTOR(HR F/RTU).....
HEAT EXCHANGER TUBES CIRCULATING(BTU/HR*F).....
ESTIMATED OPTIMUM STORAGE(LB/AREAC).....
ESTIMATED PUMPING REFERENCE.....
ESTIMATED PUMPING POWER(KWH/APLAC).....
ESTIMATED CORRECTION FOR TAN ALPHA PRPD.....
ESTIMATED INSTALL/L PER CFT (8/AREAC).....
ESTIMATED IN X COST ($/FT**2).....
ESTIMATED STORAGE TANK COST($/LB STORED).....
MAINTENANCE ($ INSTALLED COST/YR).....

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176.00	60.81	1.0000	0.3870	104.00	62.09	1.0000	0.3640	0.0010	0.0010	220.00	15.30	0.20	1.0000	0.93	10.00	5.00	0.08	0.0010
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S O L A R - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA

>>>>DATA MATCH TC INPUT ID NO. 16222
1400-1 LWR AUGUST 1975

MONTH	HORIZONTAL INSCLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/DAY	EXTRA- TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/DAY FT**2				
JAN	679.6	764.4	40.2	0.1555E 08	0.2637E C7	145C.2	1.645	0.162	
FEB	931.4	659.4	41.8	0.1337E 08	0.2382E 07	1878.0	1.429	0.219	
MAR	1281.0	527.5	48.1	0.1076E 08	0.2637E C7	2489.0	1.186	0.335	
APR	1676.7	248.0	57.9	0.5559E 07	0.2552E C7	3112.7	0.989	0.575	
MAY	1887.5	71.7	66.2	0.1463E 07	0.2637E C7	3557.7	0.868	0.842	
JUN	2000.3	4.9	74.1	0.9998E 05	0.2552E C7	3747.1	0.819	0.965	
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.843	0.958	
AUG	1680.2	0.1	76.7	0.2040E 04	0.2637E 07	3299.5	1.104	0.923	
SEP	1393.6	10.1	71.5	0.2060E 06	0.2552E C7	2725.4	1.359	0.628	
OCT	1083.0	153.5	61.2	0.3131E 07	0.2637E 07	2074.7	1.632	0.332	
NOV	811.2	403.0	51.8	0.3221E 07	0.2552E C7	1552.3	1.737	0.172	
DEC	623.8	671.9	43.3	0.1371E 08	0.2637E C7	1323.0			
TOTAL		3510.5		0.7161E 08	0.3105E 08		>>>WEIGHTED AVERAGE	0.379	
DESIGN VARIABLE/CONSTRAINTS									
COLLECTOR AREA (FT**2)						COLLECTOR SIDE CAPACITY (BTU/HR F)			0.262F 04
COLLECTOR TILT ANGLE (DEG)						STORAGE SIDE CAPACITY (BTU/HR F)			0.384E 05
COLLECTOR TUBE INNER DIA. (FT)						COLLECTOR SIDE CONVECTION COEFF			1107.4634
COLLECTOR TUBE OUTER DIA. (FT)						STORAGE SIDE CONVECTION COEFFICIENT			3578.6917
STORAGE SIDE TUBECORE INNER DIA. (FT)						COLLECTOR SIDE FLOW RATE (GPM)			5.3665
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)						STORAGE SIDE FLOW RATE (GPM)			17.1474
STORAGE SIDE FLUID VELOCITY (FT/SEC)						NORMALIZED COLLECTOR FLOW (GPM/AREAC)			0.0206
HEAT EXCHANGE LENGTH (FT)						NORMALIZED STORAGE FLOW (GPM/AREAC)			0.2564
HEAT EXCHANGE LENGTH (FT)						HEAT EXCHANGE EFFECTIVENESS			0.8294
HEX ANNULAR DIAMETER DIFFERENCE (FT)						SOLAR ENERGY DELIVERED (BTU/YEAR)			0.389E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE (FT)						TOTAL ENERGY DEMAND (BTU/YEAR)			0.103E 09
COLLECTOR SIDE REYNOLDS NUMBER						ANNUAL AVERAGE SOLAR LOAD FRACTION			0.3787
STORAGE SIDE REYNOLDS NUMBER						OBJECTIVE: NPV OF SOLAR INVESTMENT			>>>
CAPACITY RATIO (GALL/CHX)						HEX COEFFICIENT (BTU/HR F FT**2)			0.343E 04
FLOW PARAMETER 22 (GCF/FRUL)						TOTAL INSTALLATION COST (\$)			315.00
FLOW PARAMETER 21 (GCF/FRUL)						COLLECTOR FLOW FACTOR(FPP)			4703.12
									0.5474





* * * * * S I M U L A T I O N * * * * *
 * * * * * SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN * * * * *
 * * * * * RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA * * * * *
 * * * * * >>>>DATA MATCH TO INPUT ID NO. 16223 * * * * *
 * * * * * 1970-1 JAN AUGUST 1975 * * * * *

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	RTU/DAY FT**2		
JAN	679.6	764.4	40.3	0.8256E 07	0.2637E 07	1450.2	1.628	0.206
FEB	531.4	655.4	41.8	0.7078E 07	0.2382E 07	1878.0	1.421	0.275
MAR	1281.0	527.5	48.1	0.5697E 07	0.2637E 07	2485.0	1.188	0.410
APR	1676.7	248.0	57.9	0.2678E 07	0.2552E 07	3112.7	0.959	0.640
MAY	1837.5	71.7	66.2	0.7744E 06	0.2637E 07	3557.7	0.882	0.836
JUN	2000.3	4.9	74.1	0.5292E 05	0.2552E 07	3747.1	0.835	0.929
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.858	0.915
AUG	1680.2	0.1	76.7	0.1080E 04	0.2637E 07	3299.5	0.947	0.913
SEP	1395.6	10.1	71.5	0.1091E 06	0.2552E 07	2725.4	1.109	0.874
OCT	1083.0	153.5	61.2	0.1658E 07	0.2637E 07	2074.7	1.350	0.652
NOV	811.2	403.0	51.8	0.4352E 07	0.2552E 07	1552.3	1.616	0.390
DEC	623.8	671.9	43.3	0.7257E 07	0.2637E 07	1223.0	1.716	0.216
TOTAL		3510.5		0.3791E 08	0.3105E 08		AVERAGE	0.460

>>>WEIGHTED AVERAGE OTHER PARAMETERS<<<

DESIGN VARIABLES/CONSTRAINTS	COLLECTOR SIDE CAPACITY (BTU/HR)	STORAGE SIDE CAPACITY (BTU/HR)	COLLECTOR SIDE CONVECTION COEFF	STORAGE SIDE CONVECTION COEFF	COLLECTOR SIDE FLOW RATE (GPM)	STORAGE SIDE FLOW RATE (GPM)	NORMALIZED COLLECTOR FLOW (GPM/AREA)	NORMALIZED STORAGE FLOW (GPM/AREA)	HEAT EXCHANGER EFFECTIVENESS	SOLAR ENERGY DELIVERED (BTU/YEAR)	TOTAL ENERGY DEMAND (BTU/YEAR)	ANNUAL AVERAGE SOLAR LOAD FRACTION	OBJECTIVE: NPV OF SOLAR INVESTMENT	HEX COEFFICIENT (BTU/HR FT**2)	TOTAL INSTALLATION COST (\$)	COLLECTOR FLOW FACTOR(FPP)
COLLECTOR AREA (FT**2)	>>>	>>>	>>>	>>>												
COLLECTOR TILT ANGLE (DEG)	>>>	>>>	>>>	>>>												
COLLECTOR TUBE INNER DIA. (FT)																
COLLECTOR TUBE OUTER DIA. (FT)																
STORAGE TUBE (TUBE)X INNER DIA. (FT)																
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)																
STORAGE SIDE FLUID VELOCITY (FT/SEC)																
HEAT EXCHANGER LENGTH (FT)																
HEAT EXCHANGER DIAMETER (FT)																
HEX ANNULAR DIAMETER DIFFERENCE (FT)																
COLLECTOR SIDE REYNOLDS NUMBER																
STORAGE SIDE REYNOLDS NUMBER																
CAPACITY RATIO (CMIN/CMAX)																
FLOW PARAMETER Z1(CCP/FRUL)																
FLOW PARAMETER Z1(CCP/FRUL)																



LOCATION	NORFOLK VIRGINIA	COLLECTOR FEDERAL PRISON I. D	STUD
LOCATION INDEX.....	16	COLLECTOR TEST RESULTS,	ECON
LATITUDE, DEGREES.....	36.90	SLOPE:	SYST
MEAN TEMPERATURE.....	59.22	PARAMETER, FRU.....	DI SC
INSOL (R10/DAY FT*2)	1325.25	INTERCEPT:	INFL
LOAD FACTOR, HDU.....	3510.50	CALAMETER, FRTA.....	
MEAN GROUND TEMP.....	55.00	BATH COST, \$/FT*2..:	

SULFONIC ACID CATALYSTS

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COLLECTOR FUID MEAN TEMPERATURE.....
COLLECTOR FUID DENSITY(LB/FT**3).....
COLLECTOR FUID SPECIFIC HEAT(FTU/LP*F).....
COLLECTOR FUID CONDUCTIVITY(RTU/FR*F*F).....
STORAGE FUID MEAN TEMPERATURE.....
STORAGE FUID DENSITY(LB/FT**3).....
STORAGE FUID SPECIFIC HEAT(RTU/LP*F).....
STORAGE FUID CONDUCTIVITY(BTU/HR*F*F).....
COLLECTOR SIDE FOULING FACTOR(FR*F/RTU).....
STORAGE SIDE FOULING FACTOR(HE*F/RTU).....
HEX TUBE CONDUCTIVITY(BTU/FR*F*F).....
ESTIMATED OPTIMUM STORAGE(LP/APEAC).....
ESTIMATED GLUID REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AR*AC).....
ESTIMATED CORRECTION FOR TAU ALPHA PFD.....
ESTIMATED PISTALL/LABOR COST ($/F*F*2).....
ESTIMATED HEX COST ($/AR*AC).....
ESTIMATED STORAGE TANK COST($/LP*STPED).....
ESTIMATED MAINTENANCE ($ INSTALLED COST/YR).....

```

LOAD LOSS COEFFICIENT (BTU/HR-F-FT**2).....
 LOAD SURFACE HEAT TRANSFER AREA (FT**2).....
 LOAD CONDUCTANCE (BTU/DEG-F-DAY).....
 DOMESTIC HOT WATER (DEG) DESIGN TEMP.
 ESTIMATED DAILY DRINK USAGE (GAL/PER).....
 ESTIMATED NEW USERS (PER).....
 ESTIMATED STUBS TO LOAD EFFECTIVENESS.....

```

COLLECTOR FUID MEAN TEMPERATURE.....
COLLECTOR FUID DENSITY(LB/FT**3).....
COLLECTOR FUID SPECIFIC HEAT(FTU/LP*F).....
COLLECTOR FUID CONDUCTIVITY(RTU/FR*F*F).....
STORAGE FUID MEAN TEMPERATURE.....
STORAGE FUID DENSITY(LB/FT**3).....
STORAGE FUID SPECIFIC HEAT(RTU/LP*F).....
STORAGE FUID CONDUCTIVITY(BTU/HR*F*F).....
COLLECTOR SIDE FOULING FACTOR(FR*F/RTU).....
STORAGE SIDE FOULING FACTOR(HE*F/RTU).....
HEX TUBE CONDUCTIVITY(BTU/FR*F*F).....
ESTIMATED OPTIMUM STORAGE(LP/APEAC).....
ESTIMATED GLUID REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/AR*AC).....
ESTIMATED CORRECTION FOR TAU ALPHA PFD.....
ESTIMATED PISTALL/LABOR COST ($/F*F*2).....
ESTIMATED HEX COST ($/AR*AC).....
ESTIMATED STORAGE TANK COST($/LP*STPED).....
MAINTENANCE ($ INSTALLED COST/YR).....

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164

NUCLEAR ENERGY OPTIMIZATION ANALYSIS AND DESIGN

RESULTS OF ANALYSIS FOR HOPKINS VIRGINIA

>>>>DATA MATCH TO INPUT ID NO. 16232
QACD-1 CLK AUGUST 1979

0ACD-L LVK AUGUST 1979

MONTH	HORIZONTAL INSULATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	BTU/MONTH	BTU/MONTH	EXTRA- TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR RADIATION
	BTU/DAY FT*2	DEG DAY	DEG F		BTU/MONTH	BTU/DAY	FT*2		
JAN	679.6	764.4	40.3	0.1559E	08	0.2637E	07	1.634	0.162
FEB	931.4	655.4	41.8	0.1337E	08	0.2382E	07	1.423	0.216
MAR	1281.0	527.5	48.1	0.1076E	08	0.2037E	07	1.187	0.329
APR	1676.7	246.0	57.9	0.5059E	07	0.2552E	07	0.996	0.570
MAY	1887.5	71.7	66.2	0.1463E	07	0.2637E	07	0.877	0.856
JUN	2000.3	4.9	74.1	0.9996E	05	0.2552E	07	0.830	0.958
JUL	1853.2	0.0	77.7	0.0		0.2637E	07	0.853	0.990
AUG	1630.2	0.1	76.7	0.2040E	04	0.2637E	07	0.943	0.989
SEP	1395.6	10.1	71.5	0.2060E	06	0.2552E	07	1.107	0.946
OCT	1083.0	153.5	61.2	0.3191E	07	0.2637E	07	1.351	0.624
NOV	811.2	403.3	51.8	0.8221E	07	0.2552E	07	1.622	0.326
DEC	623.8	671.9	43.3	0.1371E	08	0.2637E	07	1.723	0.172
TOTAL		3510.5		0.7161E	08	0.3105E	08	>>>WEIGHTED AVERAGE	0.380

DESIGN VARIABLES/CONSTRAINTS

[illegible]



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SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPLTS SUMMARY

>>>>DATA 4ATCH TO OUTPUT ID NF. 14232
IMJD-1 LWK AUGUST 1975

LOCATION	FRESNO	CALIF	COLLECTOR	FEDERAL PRISON I. D.	STUDY APPROACH	ANALYSIS
LOCATION INDEX.....		14	COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATES	
LATITUDE, DECILES....		36.77	SLOPE:			
MEAN TEMPERATURE....		61.85	PARAMETER, FRU1	0.8830	SYSTEM LIFE(YEARS)...	20.00
INSOL (BTU/DAY FT**2)		1710.81	INTERCEPT:		DISCOUNT RATE	0.0900
LEAD FACTOR, HDD.....		2826.40	PARAMETER, FRTA.....	0.6270	INFLATION RATE	0.1100
MEAN GROUND TEMP.....		55.00	BASE COST, \$/FT #2...	9.40		

ENERGY COMPARATIVE ESTIMATES

INDEX	TYPE	HEATING OIL	TYPE	EFFICIENCY	COST	HEATING VALUE
1	CIL	0.70	0.90 (\$/GAL)	14200.0 (BTU/GAL)		
2	EFF	0.99	0.25 (\$/KWH)	3413.0 (BTU/KWH)		
3	GAS	0.73	0.40 (\$/THERM)	100000.0 (BTU/THERM)		

HEAT-LOAC CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR FT**2)...	0.17
LOCAL SURFACE FLAT TRANSFER AREA (FT**2)...	5000.00
LOAD CONDUCTANCE (BTU/DLG FT DAY)...	2039.33
DOMESTIC HOT WATER (DHW) DESIGN TEMP.	140.00
ESTIMATED DAILY HW USE (GAL/PER)	20.00
ESTIMATED DHW USERS (PER).....	0.00
ESTIMATED SPACE LVD EFFECTIVE FRS.	1.00

SELECTED PARAMETERS

```

COLLECTOR FLUID MEAN TEMPERATURE.....
COLLECTOR FLUID DENSITY(LB/FT**3).....
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).....
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F).....
STORAGE FLUID MEAN TEMPERATURE.....
STORAGE FLUID DENSITY(LB/FT**3).....
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F).....
STORAGE FLUID CONDUCTIVITY(BTU/HR*FT*F).....
COLLECTOR SIDE FUELING FACTOR(HR F/BTU).....
STORAGE SIDE FUELING FACTOR(HR F/BTU).....
HEX TUBE CONDUCTIVITY(BTU/HR*FT*F).....
ESTIMATED OPTIMUM STORAGE(LB/HR*FAC).....
ESTIMATED SPREAD REFLECTANCE.....
ESTIMATED PUMPING POWER(KWH/ARC*AC).....
ESTIMATED CORRECTION FACTOR TAU ALPHA PRD.....
ESTIMATED INSTALL/LABOR COST (1/ARC*AC).....
ESTIMATED HEX COST (1/FT**2).....
ESTIMATED STORAGE TANK COST(1/LB STOPPED).....
MAINTENANCE (% INSTALLED COST/YR).....

```

ANALYSIS

SYSTEM LIFE (YEARS) ..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE	0.1100

176.00
60.81
1.0000
0.2870
1194.00
62.09
1.0000
0.3640
0.0010
0.0010
220.00
15.30
0.20
1.0000
10.093
10.000
0.08
0.010



APPENDIX E

POTENTIAL CORRELATION FOR OPTIMUM COLLECTOR FLOW RATE

Reference [2] defines the collector heat removal factor, F_r , as:

$$F_r = \frac{Gc_p}{U_L} \left\{ 1 - \exp\left(\frac{-F'U_L}{Gc_p}\right) \right\} \quad (B1)$$

Further, the collector flow factor, F'' , is defined as,

$$F'' = \frac{F_r}{F'} = \frac{Gc_p}{F'U_L} \left\{ 1 - \exp\left(\frac{-F'U_L}{Gc_p}\right) \right\} \quad (B2)$$

Reference [2] shows that F'' approaches the unity value asymptotically as the parameter $Gc_p/U_L F'$ increases. Reference [3] recommends capacity rates of 10-15 lb/hr ft_c² (.0223 - .0334 Gpm/ft_c²) as the best compromise among collector heat transfer coefficient, fluid pressure drop, and energy delivery. The unit ft_c refers to collector area.

The results of this thesis suggested a correlation between the collector performance parameter $F_r U_L$ and the capacity rate. Once these results are verified by further testing including model changes to include fluid pressure drop, a simple correlation may be available and follows from:

Let, κ^* = The optimum flow factor determined from computer experiments.

$$\zeta_1 = Gc_p / F' U_L$$

$$\zeta_2 = Gc_p / F_r U_L$$

It follows from equations (B1) and (B2) that:

$$F'' = \frac{1}{\zeta_2}$$

$$\frac{1}{\zeta_2} = 1 - \exp(-1/\zeta_1)$$

or,

$$\zeta_1 = \frac{1}{-\ln(1 - 1/\zeta_2)}$$

Let, ζ_1^* = The optimum parameter which corresponds to κ^* and is obtained by solving equation (B2) for ζ_1

Therefore,

$$\kappa^* = \frac{\zeta_1^*}{\zeta_2}$$

or

$$\zeta_2 = \frac{\zeta_1^*}{\kappa^*}$$

or

$$Gc_p / F_r U_L = \frac{\zeta_1^*}{\kappa^*}$$



or,

$$G = \frac{\zeta_1^*}{\kappa^*} F_r U_L / c_p$$

or,

$$G = \kappa^{**} F_r U_L$$

Based on the results of a limited number of computer experiments all yielding an apparent invariant flow factor, $F'' = .948$:

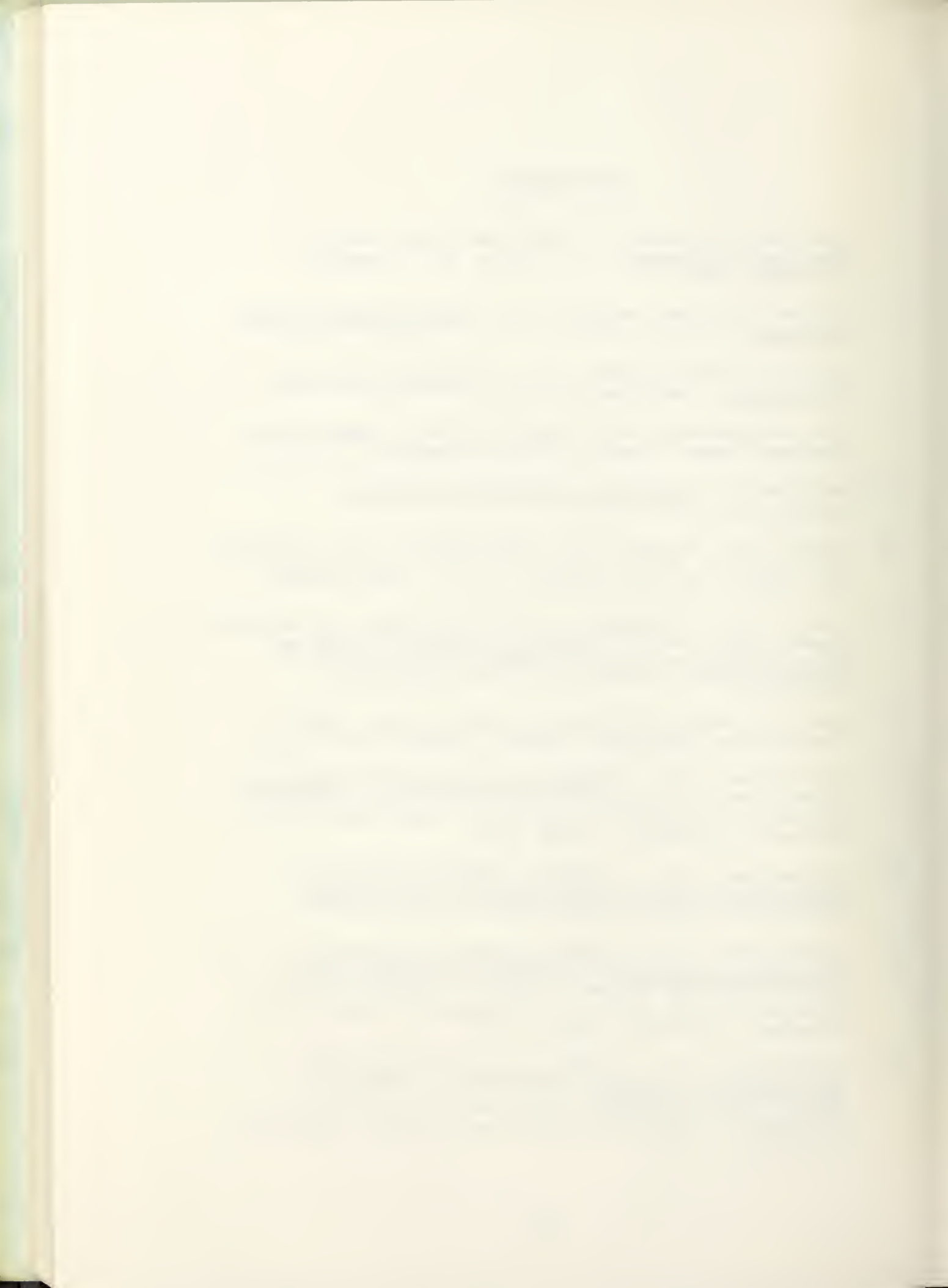
$$\kappa^{**} = .01955 \text{ (Gpm hr F/Btu)}$$

Or,

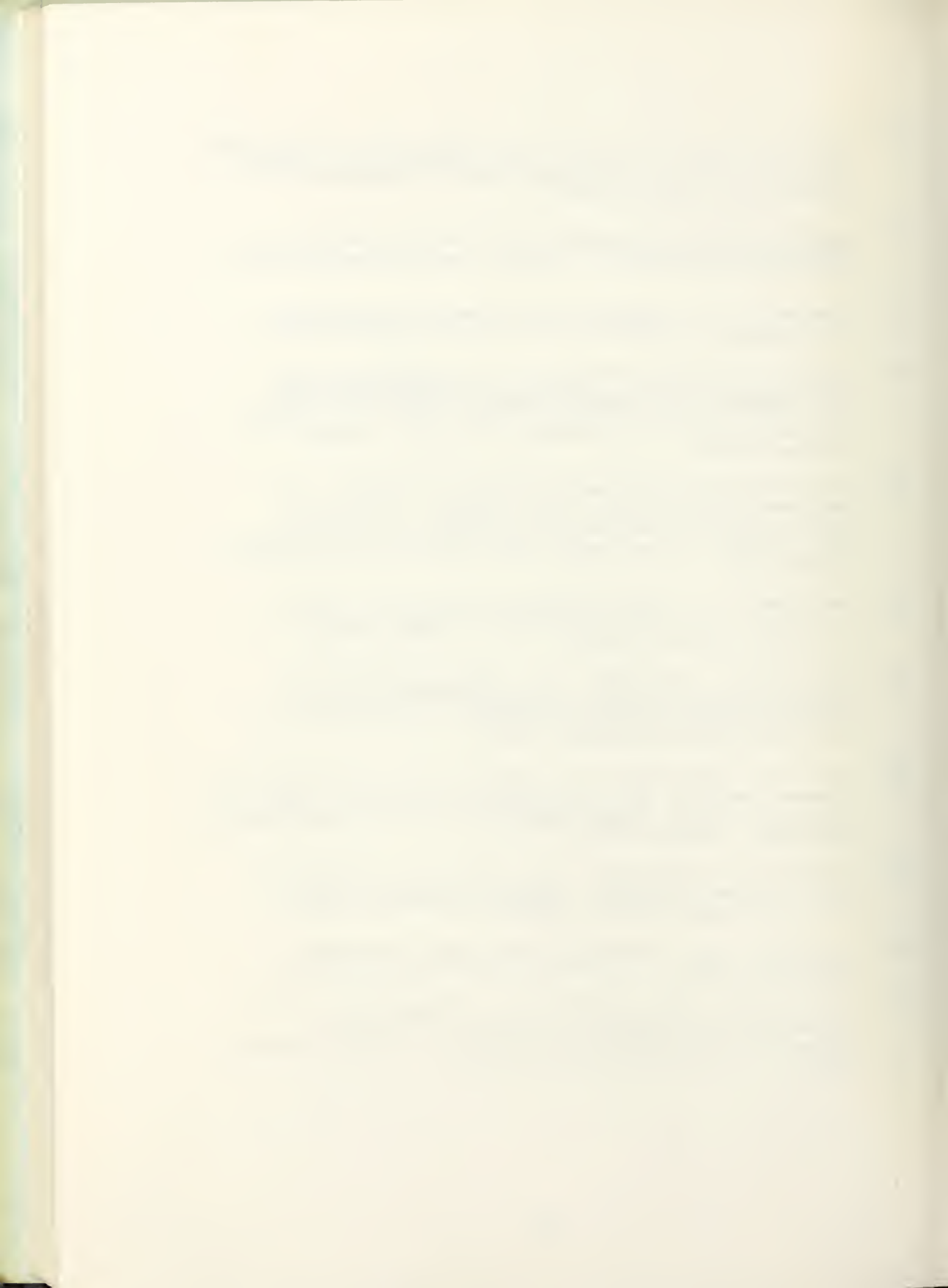
$$G = .01955 F_r U_L \text{ (Gpm/ft}_c^2\text{)}$$

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